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POST INJECTION STANDARD TRAJECTORY RANGER P-36 (RA-5) VOL. I

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FOREWORD

For the RA-5 lunar mission, the trajectories defined in EPD No. 4 are obsolete. The updated RA-5 standard trajectories are based on the launch dates in the confidential addendum of this document.

Generally, the information contained in EPD No. 105 pertains to the postinjection phase of the trajectory. The publication of the complete RA-5 standard trajectories are contained in the Space Technology Laboratories, Incorporated document, Launch to Impact Targeting Trajectory, Ranger-5, No. 8990-6011-TC001.

A Trajectory Listing of the JPL Standard Trajectory will be presented in Vol. II. This listing gives trajectory conditions at injection and lunar impact for each day launch at launch azimuths of 93, 102, 111 degrees. Vol II will be distributed after Oct. 6, 1962.

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SECTION I

INTRODUCTION

For lunar missions, the standard trajectory must have time-variant characteristics in order to compensate for changes in celestial geometry within the firing window.* Such time-variant characteristics must be considered in engineering design and may be observed by examination of a set of trajectories as presented in this document which cover the variations expected throughout the firing windows under consideration.

The Ranger schedule has been altered since the publication of EPD No. 4 (EPD No. 4 is now obsolete). The current RA-5 launch dates are presented in the confidential addendum to this report. Changes in schedule affect the lunar missions because of the continuously changing position of the celestial bodies. The result of the latest schedule change was to shift the injection locations over the Earth's surface and to alter the flight time (and, therefore, the impact speed).

A. MISSION

1. Objectives

The RA-5 mission is the third of three (RA-3, RA-4, and RA-5) lunar impact missions designed to achieve the following objectives:

(a) To collect gamma ray data in flight and at the vicinity of the Moon.

(b) To obtain photographs of the surface of the Moon.

(c) To transmit lunar seismic data after landing.

(d) To experiment with a trajectory error correction.

(e) To experiment with the terminal attitude maneuver.

(f) To continue development of basic spacecraft technology.

2. Launch vehicle

The launch vehicle consists of a Convair D Mod. II first stage and a Lockheed Agena B second stage.

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* See page I-3

3. Spacecraft

The Ranger 5 spacecraft (P-36) demonstrates an advanced concept in spacecraft design. Attitude and control capabilities provide space-stabilization and control throughout flight. A midcourse correcting guidance and terminal attitude reference maneuver are commanded from the Goldstone tracking station. For the RA-5 mission, the scientific experiments will consist of the gamma ray, lunar seismometer and vidicon experiments. The seismometer is contained in a capsule designed to withstand a semisoft landing on the Moon following a retrorocket maneuver designed to minimize the lunar impact velocity.

B. TRAJECTORY

A trajectory may be considered as being comprised of two parts; the preinjection phase, and the postinjection phase. The preinjection phase consists of all powered flight and coast periods from launch to injection (burnout of the last stage). The postinjection phase consists of the coast period from injection to lunar impact.

1. Preinjection phase

The Agena/Ranger combination is boosted in turn by the Atlas and Agena stages into a 100 nautical mile circular parking orbit. The Agena/Ranger coasts in the parking orbit until reaching the vicinity of perigee of the lunar transfer ellipse. The Agena second burn then provides the required final velocity increment prior to spacecraft injection.

2. Postinjection phase

For RA-5 trajectories, injection occurs about 3.3 degrees past perigee of the geocentric conic resulting in a transfer ellipse with lunar flight times (from injection) close to 66 hours. This flight time interval was selected upon the basis of visibility of lunar impact with regard to the Goldstone tracking station and certain guidance accuracy considerations.

C. LAUNCH PHILOSOPHY

1. Launch period

The launch period of the RA-5 mission was determined primarily by engineering constraints imposed by attitude and control and the scientific experiments. The first day in the launch period was determined by the minimum allowable Earth-Probe-Sun (EPS) angle of 73 degrees near lunar encounter (see Fig.28). This minimum EPS angle is required to ensure that sunlight will not bias the light reflected from Earth as observed by the spacecraft earth sensor. The last day of the launch period was determined by the lunar arrival conditions. Throughout the period for which lunar impact occurs changes in lunar lighting are characterized by the terminator advancing approximately 14 degrees per day across the lunar surface. (See Fig. 33). The combined constraints of impact lighting conditions and location of impact from the Earth-Moon line limit the launch period to four consecutive days near lunar third quarter.

Trajectories for four launch dats near lunar third quarter are presented in this document to encompass all acceptable launch dates for the month under consideration. These launch dates are given in the confidential addendum to this document.

2. Firing window

A combination of launch times which comprise the firing window may be achieved only by accumulating a range of permissible launch azimuths. This dependency results from the fact that due to the continuous change in the geometry of the celestial bodies each discreet launch azimuth has but one appropirate launch time.

For the RA-5 mission the launch azimuths are restricted between 93 and 111 degrees by range safety considerations. The actual permissible launch azimuths within this range are determined by telemetry and tracking considerations. The firing windows for the RA-5 mission, as dictated by the actual permissible launch azimuths, can be found by examining Figure 10. This figure presents the Greenwich Mean Time (GMT) of launch as a function of launch azimuth for each launch day.

D. SEQUENCE OF EVENTS

The RA-5 sequence of events is shown schematically in figures 2 through 5. Specific times for certain events vary depending upon launch time and launch day. Selected event times from launch versus launch azimuth are shown in figures 12 and 13.

E. SUNLIGHT CONDITIONS DURING FLIGHT

Because the RA-5 standard trajectories are designed to impact the Moon during the lunar day, the probe will be in direct sunlight except for brief periods during its travel in the vicinity of the Earth. The probe never enters the shadow of the Moon. The time that the spacecraft spends in the earth's shadow will vary according to launch date and launch azimuth as shown in table II and figures 12 and 13.

F. CONSTRAINTS ON ARRIVAL CONDITIONS AT MOON

For the most part, the lunar arrival conditions are constrained by the lunar impact time, the vidicon experiment, and seismometer experiment.

1. Lunar impact time constraint

   a. Lunar impact for the standard trajectories must not occur earlier than three hours after the spacecraft rises on the Goldstone tracking station horizon. Two hours are required to perform the following: 1) acquire and track the spacecraft, 2) verify the orbit, 3) transmit and confirm transmission of the terminal maneuver command to the spacecraft, 4) initiate the terminal maneuver 65 minutes prior to impact. Another hour is specified as the three sigma dispersion in the time of arrival.

   b. Lunar impact for the standard trajectories must not occur earlier than one hour before the capsule reaches the Goldstone tracking station telemetry limit. This will provide reception of telemetry to lunar impact. The one hour is again specified as the three sigma dispersion in the time of arrival.

2. Vidicon experiment constraints

   a. For photographic purposes the lighting angle (Sun-Moon-Probe angle) at lunar impact should be between 55 to 65 degrees.

   b. The unretarded impact velocity vector should be within 25 degrees of the local vertical. Non-vertical impact trajectories (biased) reduce the amount of nesting of the vidicon pictures during the final descent. The vidicon camera will be aligned parallel to the unretarded velocity vector at impact.

3. Seismometer experiment constraints

   a. The unretarded impact velocity is to be nearly constant for all launch days during the launch period. This constraint is specified in order that a fixed impulse retro-rocket and capsule combination may be used. This condition implies that the second Agena cutoff constant may be fixed for any given launch day but must be changed between launch days throughout the launch period.

   b. The Earth-Moon-Probe angle should be less than 55 degrees during the three month period following lunar impact. This will keep the Earth within the lobes of the seismometer antenna pattern to give acceptable Moon to Earth signal strength.

G. SELECTION OF IMPACT LOCATIONS FOR THE RA-5 STANDARD TRAJECTORIES

Originally the RA-5 standard trajectories were designed to descend vertically onto the lunar surface. However the lighting conditions change so rapidly each day that the required lighting conditions could be met only by biasing the trajectories from the vertical impact locations (see figure 33). From the range of impact locations at a constant distance from the terminator where the required lighting conditions are satisfied desirable impact locations could be selected. The selections must of course keep in mind the remaining constraints on lunar arrival conditions, i.e., the Earth-Moon-Probe angle at impact and the angle between the unretarded velocity vector at impact and the local vertical.

The vertical impact locations and the selected biased impact locations are shown in figure 33. Except for the first day launch the standard trajectories impact at the selected impact locations. For the first day launch two possible impact locations were selected. The standard trajectories for the first day launch impact between the two selected impact locations and have, except for location, nearly the same impact conditions.

H. MOON ARRIVAL CONDITIONS

The unretarded velocity vector at impact is canted from the local vertical by approximately two thirds the amount the biased impact location is from the vertical impact location (great circle arc measured on the moon's surface). This velocity vector lies in a plane defined by the vertical and biased impact locations and the Moon's center. The nominal unretarded impact velocity is 2.612 kilometers per second. The impact geometry and lighting conditions are shown in figure 33 for each day launch.

I. EXPLANATION OF TABLES III-1 TO III-4

The trajectory conditions tabulated under "JPL" are taken from the RA-5 trajectories designed by the Jet Propulsion Laboratory (JPL) using approximate preinjection trajectory characteristics to achieve the impact conditions outlined in paragraph G - Selection of Impact Location for the RA-5 Standard Trajectories. Impact conditions from these JPL trajectories were specified to Space Technology Laboratories, Incorporated (STL) as design criteria for the STL launch to impact targeting trajectories (ref. 1). These STL trajectories were generated with simulated actual flight conditions. Trajectory conditions from the STL targeting trajectories are tabulated under "STL".

The impact conditions of the STL targeting trajectories are not the exact <u>desired</u> impact conditions. However, the differences are small when compared with those which may result from inaccuracies in the over-all guidance system. For all expected flight conditions, the midcourse maneuver is designed to correct the actual flight trajectory to achieve the <u>desired</u> impact conditions.

The STL targeting trajectories best represent the actual flight injection conditions while the JPL standard trajectories best represent the actual flight impact conditions.

The coordinates of injection, except for inertial speed, are all relative to a rotating Earth. Path angle is measured from the geocentric local horizontal plane and azimuth angle is measured in the geocentric local horizontal plane eastward from true north. Geocentric latitude is measured positive north of the Earth's equator and geocentric longitude is measured positive east of Greenwich meridian.

The coordinate of impact except for inertial speed, are relative to a rotating Moon. Path angle is measured from the selenocentric local horizontal plane and azimuth angle is measured in the selenocentric local horizontal plane eastward from the selenocentric north direction. The selenocentric latitude and longitude are defined in figure 34. The geocentric latitude and longitude are as defined above except for the probe at impact. The miss parameters B•T and B•R are defined in the nomenclature.

The Earth-Moon-Probe angle indicates the impact location on the lunar surface referenced to the Earth-Moon line. The lighting angle is the angle between the Moon-Sun line and the impact vertical, and indicates the time of impact during the lunar afternoon.

J. TRACKING CHARACTERISTICS

Maps showing the Earth track of the 93, 102, and 111 degree launch azimuth trajectories for each launch day are shown in figures 6 to 9. The viewing periods for selected tracking stations in GMT vs launch azimuth from launch to impact are shown in figures 14 to 17. The station elevation angle vs time for the first hours past injection are presented for Johannesburg and Woomera in figures 19 to 26. For detailed analysis, a complete set of post-injection trajectories with station parameters are stored on magnetic tape and are available on request from W. E. Kirhofer, Jet Propulsion Laboratory, Extension 1317.

SECTION II

TABLES

Table I. Firing Windows

LAUNCH DAY	FIRING WINDOW (FOR A LAUNCH AZIMUTH RANGE FROM 93 TO 111 DEGREES) MINUTES
1	170
2	167
3	162
4	154

*A DISCUSSION OF FIRING WINDOWS IS PRESENTED ON PAGE I-3.

Table II. Lighting Conditions During Flight

Launch Day	Launch Azimuth	Enter Earth's Shadow		Leave Earth's Shadow		Time Spent Earth's Shadow	Injection Time	
		GMT		GMT			GMT	
	Degrees	Hr.	Min.	Hr.	Min.	Min.	Hr.	Min.
1	93	14	54.2	15	19.8	25.6	14	50.3
	102	16	15.2	16	37.3	22.1	16	11.3
	111	17	36.8	17	51.6	14.8	17	32.1
2	93	15	57.8	16	19.5	21.7	15	58.0
	102	17	17.7	17	37.5	19.8	17	18.1
	111	18	36.7	18	53.2	16.5	18	37.2
3	93	17	9.9	17	30.6	20.7	17	14.0
	102	18	27.7	18	47.6	19.9	18	32.1
	111	19	42.8	20	1.1	18.3	19	47.6
4	93	18	26.5	18	48.6	22.1	18	34.9
	102	19	41.0	20	2.8	21.8	19	49.7
	111	20	51.2	21	12.5	21.3	21	00.5

Table III-1. RA-5 Trajectory Conditions For First Day Launch

	93° LAUNCH AZIMUTH		102° LAUNCH AZIMUTH		111° LAUNCH AZIMUTH	
INJECTION	JPL	STL	JPL	STL	JPL	STL
TIME, GMT (HR. MIN. SEC.)	14 50 34	14 50 19	16 11 19	16 11 16	17 32 07	17 32 08
TIME AFTER LAUNCH (SEC.)	2342.985	2344.0078	2080.199	2080.7579	1825.219	1825.7580
RADIUS (METERS)	6571528.5	6571201.4	6571072.6	6570809.7	6570557.8	6570363.3
SPEED (METERS/SEC)	10530.639	10531.116	10538.481	10538.872	10555.528	10555.799
PATH ANGLE (DEG)	1.6862806	1.7008629	1.6858042	1.7001696	1.6834504	1.6977043
AZIMUTH ANGLE (DEG)	105.98592	106.00441	108.67641	108.71325	113.82240	113.86227
GEOCENTRIC						
LATITUDE (DEG)	-24.232893	-24.257425	-24.703868	-24.721847	-25.604231	-25.625054
LONGITUDE (DEG)	50.962196	51.042675	31.391678	31.438279	11.591792	11.634196
SPEED, INERTIAL (METERS/SEC)	10951.205	10951.540	10951.590	10951.816	10952.024	10952.093
IMPACT (UNRETARDED)						
FLIGHT TIME FROM INJECTION (HR)	66.054844	66.025454	66.172390	66.176942	66.285082	66.335935
TIME, GMT (HR. MIN. SEC.)	08 53 51	8 51 51	10 21 40	10 21 53	11 49 13	11 52 17
GEOCENTRIC						
LATITUDE (DEG)	20.795708	20.800607	20.776234	20.776586	20.751427	20.755621
LONGITUDE (DEG)	303.96588	304.45118	282.80333	282.75431	261.70180	260.96499
SELENOCENTRIC						
LATITUDE (DEG)	-16.465008	-15.587645	-16.940107	-16.987188	-17.717905	-16.666164
LONGITUDE (DEG)	347.01664	346.68100	346.95531	346.10714	346.88482	346.15882
SPEED (METERS/SEC)	2609 3862	2609.7061	2610.4693	2610.7261	2613.3132	2613.1599
PATH ANGLE (DEG)	-66.937180	-67.455656	-66.888876	-67.326672	-66.761662	-67.533487
AZIMUTH ANGLE (DEG)	123.40601	125.17599	123.25186	126.72812	122.89387	124.19300
EARTH-MOON-PROBE ANGLE (DEG)	28.038062	27.732251	28.324560	28.976213	28.818619	28.663820
LIGHTING ANGLE (DEG)	59.121824	58.605203	59.859138	59.074182	60.647815	59.769517
MISS PARAMETERS						
B • T (KM)	1358.2481	1344.6246	1358.0429	1318.4857	1358.1746	1331.7547
B • R (KM)	925.19216	880.94279	925.43700	929.49176	925.22240	872.86498
SPEED, INERTIAL (METERS/SEC)	2610.8427	2610.8127	2611.9275	2611.7921	2614.7787	2614.2532

Table III-2. RA-5 Trajectory Conditions for Second Day Launch

	93° LAUNCH AZIMUTH		102° LAUNCH AZIMUTH		111° LAUNCH AZIMUTH	
	JPL	STL	JPL	STL	JPL	STL
INJECTION						
TIME, GMT (HR. MIN. SEC.)	15 58 16	15 58 03	17 18 06	17 18 05	18 37 05	18 37 11
TIME AFTER LAUNCH (SEC.)	2299.201	2300.0275	2038.442	2038.7776	1788.156	1788.2776
RADIUS (METERS)	6571536.0	6571160.7	6571075.9	6570810.7	6570561.1	6570326.0
SPEED (METERS/SEC)	10532.152	10532.684	10540.011	10540.426	10557.076	10557.458
PATH ANGLE (DEG)	1.6869841	1.7018318	1.6863967	1.7008133	1.6839276	1.6982536
AZIMUTH ANGLE (DEG)	107.30877	107.32922	109.94645	109.98734	114.95796	115.00924
GEOCENTRIC						
LATITUDE (DEG)	-23.412059	-23.438302	-23.799472	-23.818948	-24.600184	-24.621523
LONGITUDE (DEG)	48.014296	48.081490	28.611392	28.640222	9.1910870	9.2014065
SPEED, INERTIAL (METERS/SEC)	10952.596	10952.973	10952.984	10953.215	10953.418	10953.555
IMPACT (UNRETARDED)						
FLIGHT TIME FROM INJECTION (HR)	67.670709	67.629919	67.778808	67.773051	67.882411	67.912641
TIME, GMT (HR. MIN. SEC.)	11 38 31	11 35 51	13 04 50	13 04 28	14 30 02	14 31 57
GEOCENTRIC						
LATITUDE (DEG)	19.861439	19.867222	19.772631	19.772965	19.680480	19.681622
LONGITUDE (DEG)	276.97347	277.61701	256.13433	256.22271	235.56217	235.10086
SELENOCENTRIC						
LATITUDE (DEG)	-11.506836	-11.023003	-11.955196	-12.152318	-12.664957	-12.033807
LONGITUDE (DEG)	338.12429	338.37857	337.97806	337.78519	337.75459	337.42875
SPEED (METERS/SEC)	2609.4130	2609.6936	2610.8803	2609.8663	2614.2316	2613.2521
PATH ANGLE (DEG)	-74.577318	-74.619425	-74.534053	-74.540287	-74.433828	-74.831888
AZIMUTH ANGLE (DEG)	123.65092	121.44359	123.57531	123.31883	123.34880	121.24851
EARTH-MOON-PROBE ANGLE (DEG)	31.751844	31.351019	31.976555	32.224605	32.370272	32.435597
LIGHTING ANGLE (DEG)	62.747519	62.903852	63.374995	63.207696	63.954459	63.562629
MISS PARAMETERS						
B · T (KM)	955.87772	966.20376	955.76712	949.06446	956.22561	943.05218
B · R (KM)	581.25665	555.57076	581.47871	594.23843	581.10670	550.26892
SPEED, INERTIAL (METERS/SEC)	2610.4215	2610.5149	2611.8909	2610.6619	2615.2483	2614.0515

Table III-3. RA-5 Trajectory Conditions For Third Day Launch

	93° LAUNCH AZIMUTH		102° LAUNCH AZIMUTH		111° LAUNCH AZIMUTH	
INJECTION	JPL	STL	JPL	STL	JPL	STL
TIME, GMT (HR. MIN. SEC.)	17 14 39	17 14 01	18 32 12	18 32 08	19 47 31	19 47 33
TIME AFTER LAUNCH (SEC.)	2209.742	2212.0316	1955.420	1955.7818	1715.771	1716.0318
RADIUS (METERS)	6571540.5	6571184.1	6571074.6	6570831.0	6570561.5	6570345.4
SPEED (METERS/SEC)	10532.962	10533.448	10540.843	10541.254	10557.930	10558.328
PATH ANGLE (DEG)	1.6871284	1.7018528	1.6863404	1.7007360	1.6836570	1.6979980
AZIMUTH ANGLE (DEG)	109.82201	109.83362	112.28431	112.32446	117.00151	117.04997
GEOCENTRIC						
LATITUDE (DEG)	-21.546189	-21.577225	-21.838869	-21.862320	-22.518553	-22.544270
LONGITUDE (DEG)	42.114970	42.285585	23.207263	23.235127	4.6203369	4.6379693
SPEED, INERTIAL (METERS/SEC)	10953.140	10953.481	10953.533	10953.744	10953.965	10954.109
IMPACT (UNRETARDED)						
FLIGHT TIME FROM INJECTION (HR)	69.513785	69.480020	69.604833	69.585698	69.693545	69.703832
TIME, GMT (HR. MIN. SEC.)	14 45 28	14 42 49	16 08 29	16 07 16	17 29 08	17 29 47
GEOCENTRIC						
LATITUDE (DEG)	17.709650	17.719794	17.568562	17.571055	17.427999	17.430845
LONGITUDE (DEG)	243.86357	244.50598	223.78217	224.07204	204.27024	204.11339
SELENOCENTRIC						
LATITUDE (DEG)	-2.5910169	-1.4446147	-2.9590129	-3.2091748	-3.5417066	-2.8181459
LONGITUDE (DEG)	325.2083	325.42426	324.99670	325.67332	324.62411	324.88105
SPEED (METERS/SEC)	2609.8100	2609.8860	2611.5215	2611.4802	2615.1525	2613.8850
PATH ANGLE (DEG)	-85.539599	-85.520275	-85.523742	-85.008095	-85.497966	-85.391031
AZIMUTH ANGLE (DEG)	104.17709	91.925023	104.16951	102.55415	104.17142	95.135510
EARTH-MOON-PROBE ANGLE (DEG)	41.490979	41.257704	41.653325	40.988949	41.987082	41.707957
LIGHTING ANGLE (DEG)	62.746987	62.879203	63.256813	63.930236	63.599828	63.811639
MISS PARAMETERS						
B · T (KM)	328.68412	333.13383	328.79045	363.91736	328.42463	339.49832
B · R (KM)	52.283844	-7.9647306	87.133930	62.110780	52.420646	13.764083
SPEED, INERTIAL (METERS/SEC)	2610.1632	2610.1923	2611.8755	2611.8079	2615.5084	2614.1948

Table III-4. RA-5 Trajectory Conditions For Fourth Day Launch

	93° LAUNCH AZIMUTH		102° LAUNCH AZIMUTH		111 LAUNCH AZIMUTH	
INJECTION	JPL	STL	JPL	STL	JPL	STL
TIME, GMT (HR. MIN. SEC.)	18 35 08	18 34 53	19 49 50	19 49 42	21 00 36	21 00 32
TIME AFTER LAUNCH (SEC.)	2087.212	2088.5233	1841.336	1842.2733	1615.403	1616.0233
RADIUS (METERS)	6571539.4	6571260.8	6571070.5	6570871.8	6570563.7	6570422.2
SPEED (METERS/SEC)	10533.206	10533.620	10541.103	10541.464	10558.208	10558.525
PATH ANGLE (DEG)	1.6870473	1.7014790	1.6859852	1.7003174	1.6829893	1.6973629
AZIMUTH ANGLE (DEG)	112.82285	112.84338	115.07339	115.10442	119.45150	119.49283
GEOCENTRIC						
LATITUDE (DEG)	-18.624851	-18.660943	-18.833009	-18.866077	-19.400153	-19.427324
LONGITUDE (DEG)	34.307299	34.399776	16.045194	16.109501	358.52687	358.56913
SPEED, INERTIAL (METERS/SEC)	10953.003	10953.246	10953.399	10953.562	10953.826	10953.910
IMPACT (UNRETARDED)						
FLIGHT TIME FROM INJECTION (HR)	71.414113	71.401449	71.486367	71.485436	71.559283	71.567280
TIME, GMT (HR. MIN. SEC.)	17 59 58	17 58 58	19 19 01	19 18 50	20 34 09	20 34 34
GEOCENTRIC						
LATITUDE (DEG)	14.505597	14.517583	14.330375	14.338970	14.161279	14.165119
LONGITUDE (DEG)	208.13117	208.38158	188.97581	189.02500	170.76261	170.66370
SELENOCENTRIC						
LATITUDE (DEG)	-7.6422277	-5.2203920	-7.9502377	-5.8259383	-8.4378260	-7.3678186
LONGITUDE (DEG)	310.26571	310.07087	309.99680	309.48912	309.54120	309.71236
SPEED (METERS/SEC)	2610.4588	2610.2765	2612.2704	2611.6301	2615.9838	2615.1857
PATH ANGLE (DEG)	-83.987330	-84.596639	-83.964384	-84.307024	-83.923199	-84.434002
AZIMUTH ANGLE (DEG)	237.22123	251.95233	237.29757	250.51526	237.36893	241.08174
EARTH-MOON-PROBE ANGLE (DEG)	55.185139	55.312944	55.390003	55.829091	55.791052	55.577887
LIGHTING ANGLE (DEG)	62.041531	61.614958	62.467787	61.758640	62.697078	62.754734
MISS PARAMETERS						
B . T (KM)	-332.16420	-357.44267	-332.40175	-371.46760	-332.43546	-330.06274
B . R (KM)	277.18126	153.28726	277.26136	170.73059	277.34416	221.47260
SPEED, INERTIAL (METERS/SEC)	2610.0593	2609.9496	2611.8694	2611.2907	2615.5803	2614.8827

SECTION III

FIGURES

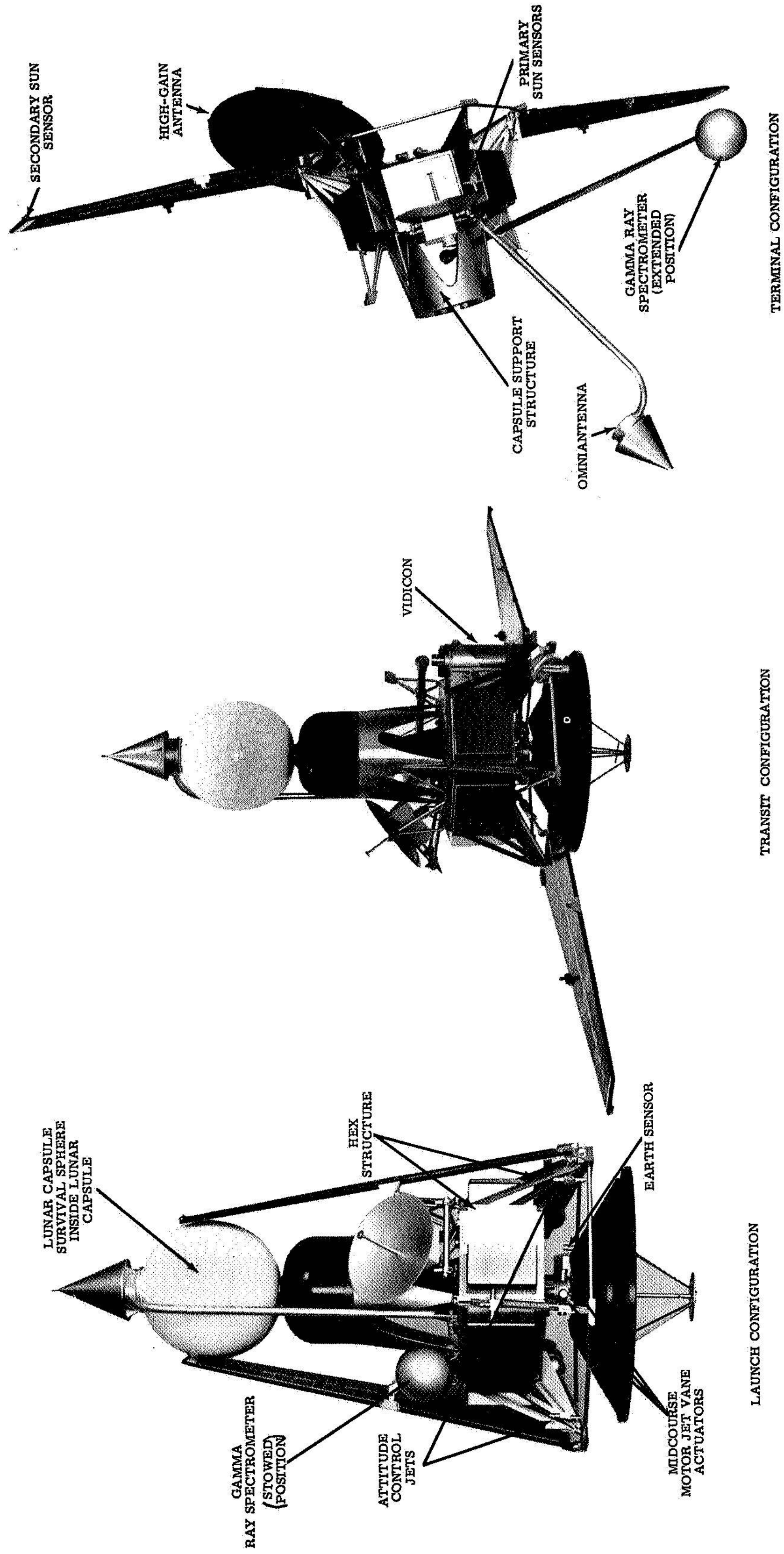
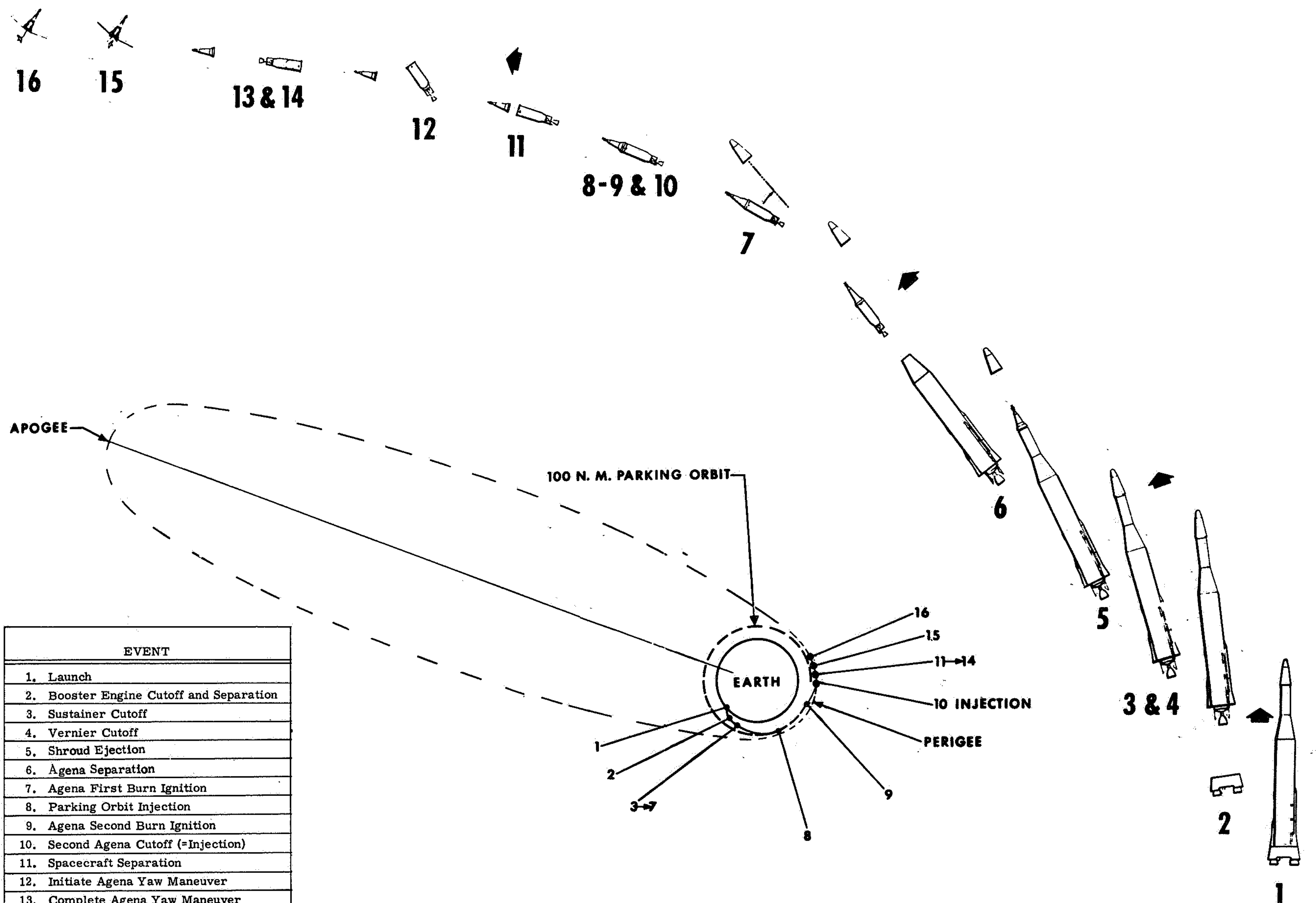


Figure 1. Spacecraft Configuration



EVENT
1. Launch
2. Booster Engine Cutoff and Separation
3. Sustainer Cutoff
4. Vernier Cutoff
5. Shroud Ejection
6. Agena Separation
7. Agena First Burn Ignition
8. Parking Orbit Injection
9. Agena Second Burn Ignition
10. Second Agena Cutoff (=Injection)
11. Spacecraft Separation
12. Initiate Agena Yaw Maneuver
13. Complete Agena Yaw Maneuver
14. Ignite Agena Retro Rocket
15. Spacecraft Sun Acquisition
16. Spacecraft Earth Acquisition

Figure 2. Sequence of Events to Earth Acquisition

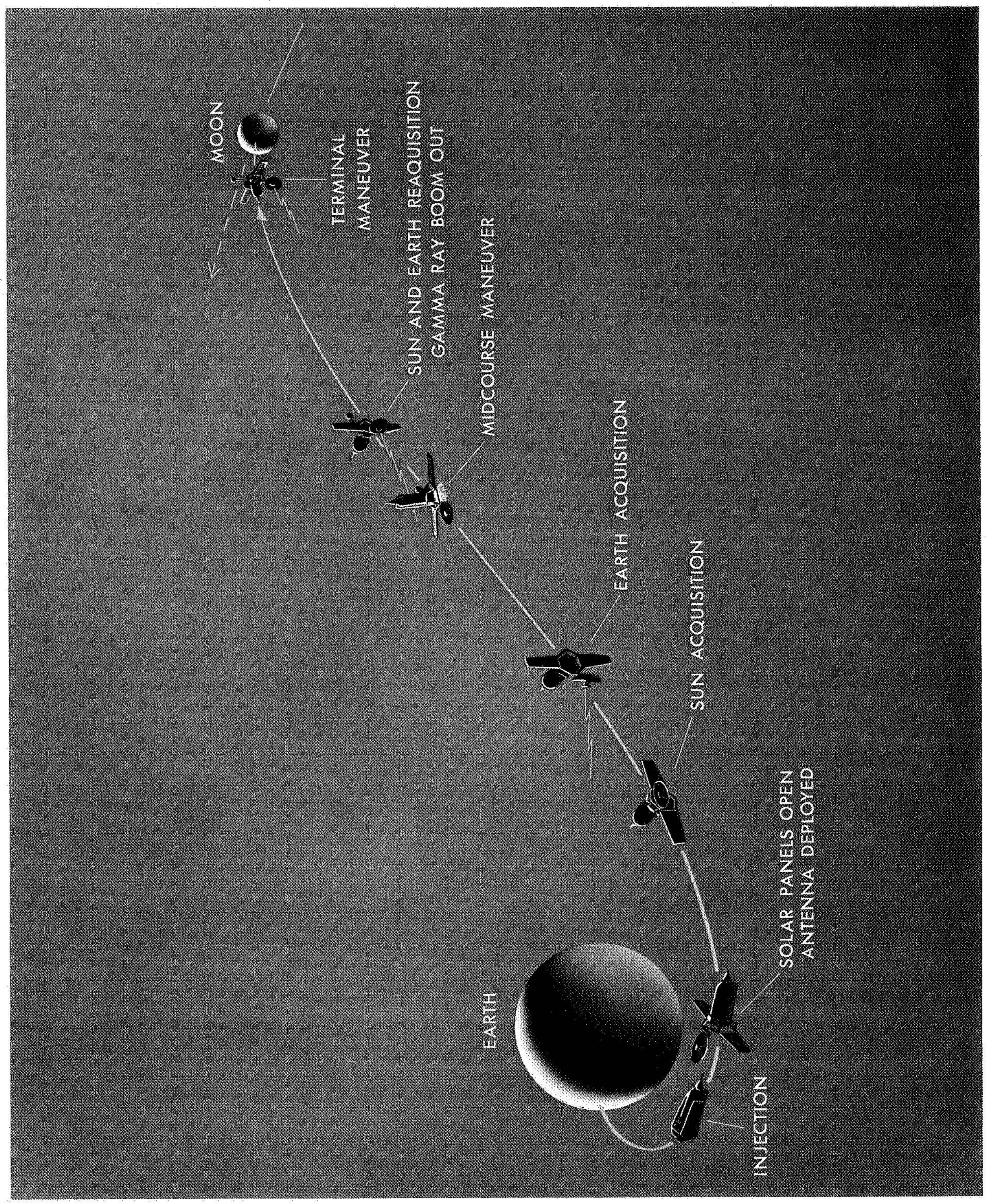


Figure 3. Overall-All Sequence of Events

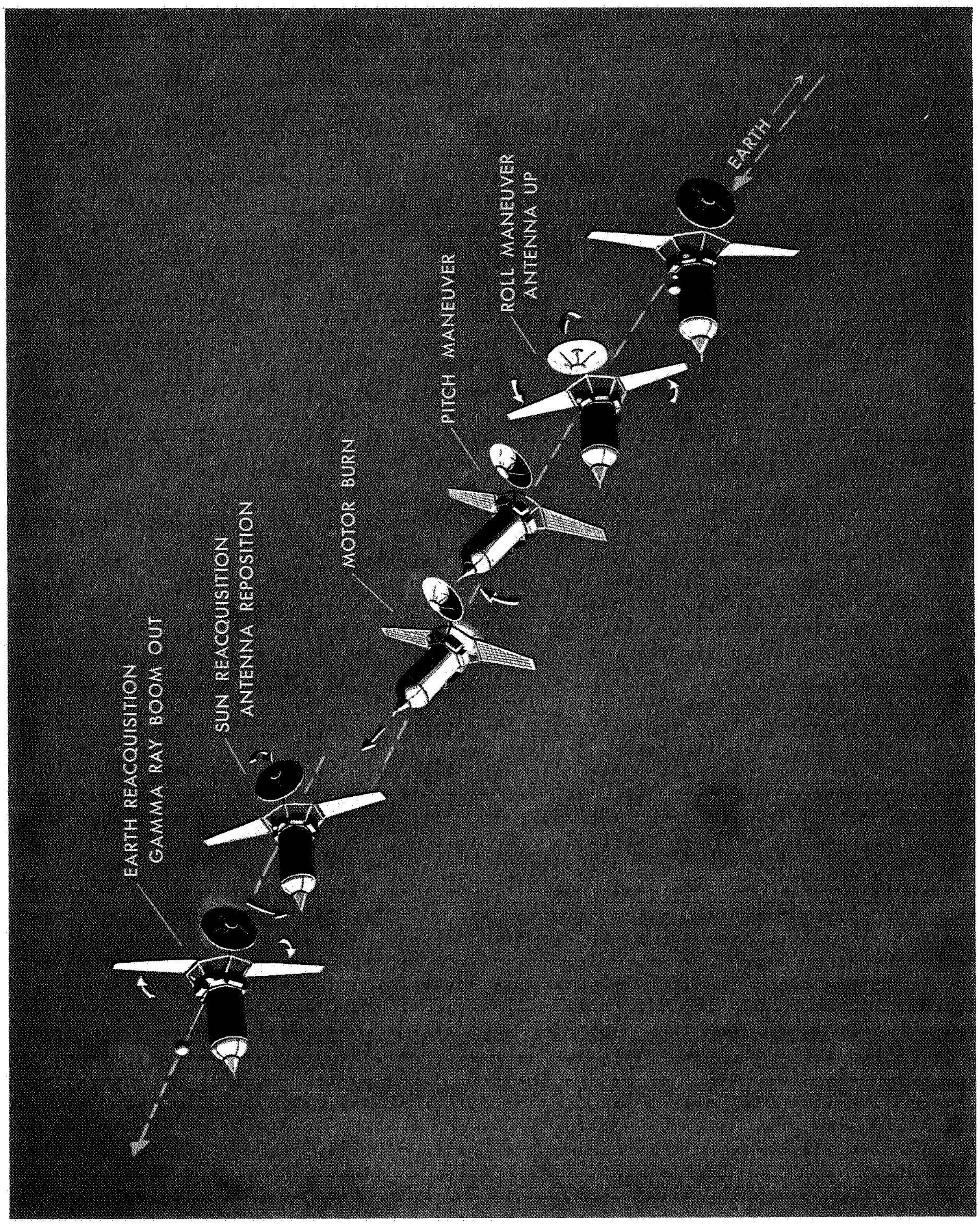


Figure 4. Sequence of Events - Midcourse Maneuver

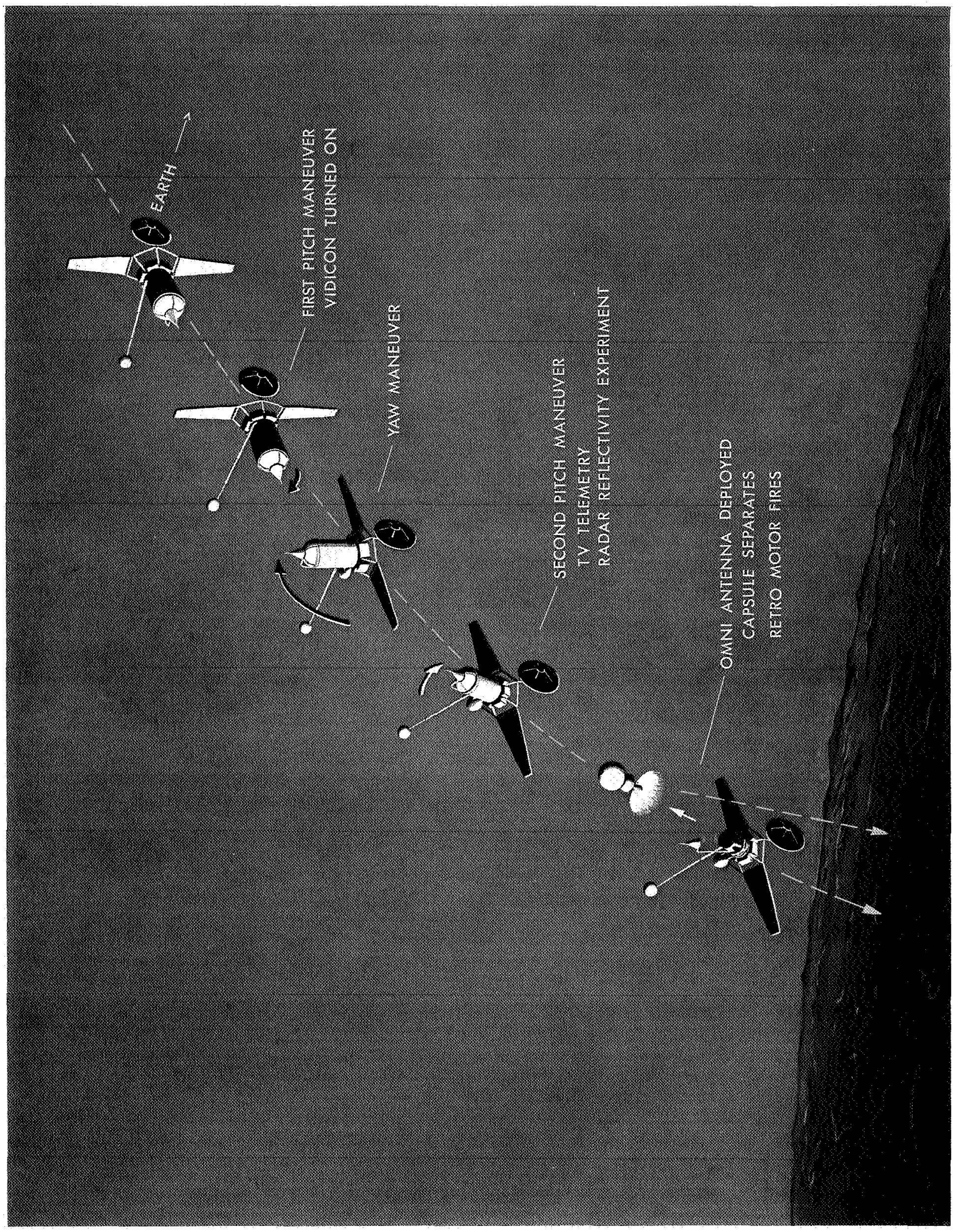


Figure 5. Sequence of Events - Terminal Maneuver

Figure 6. Earth Track First Day Launch

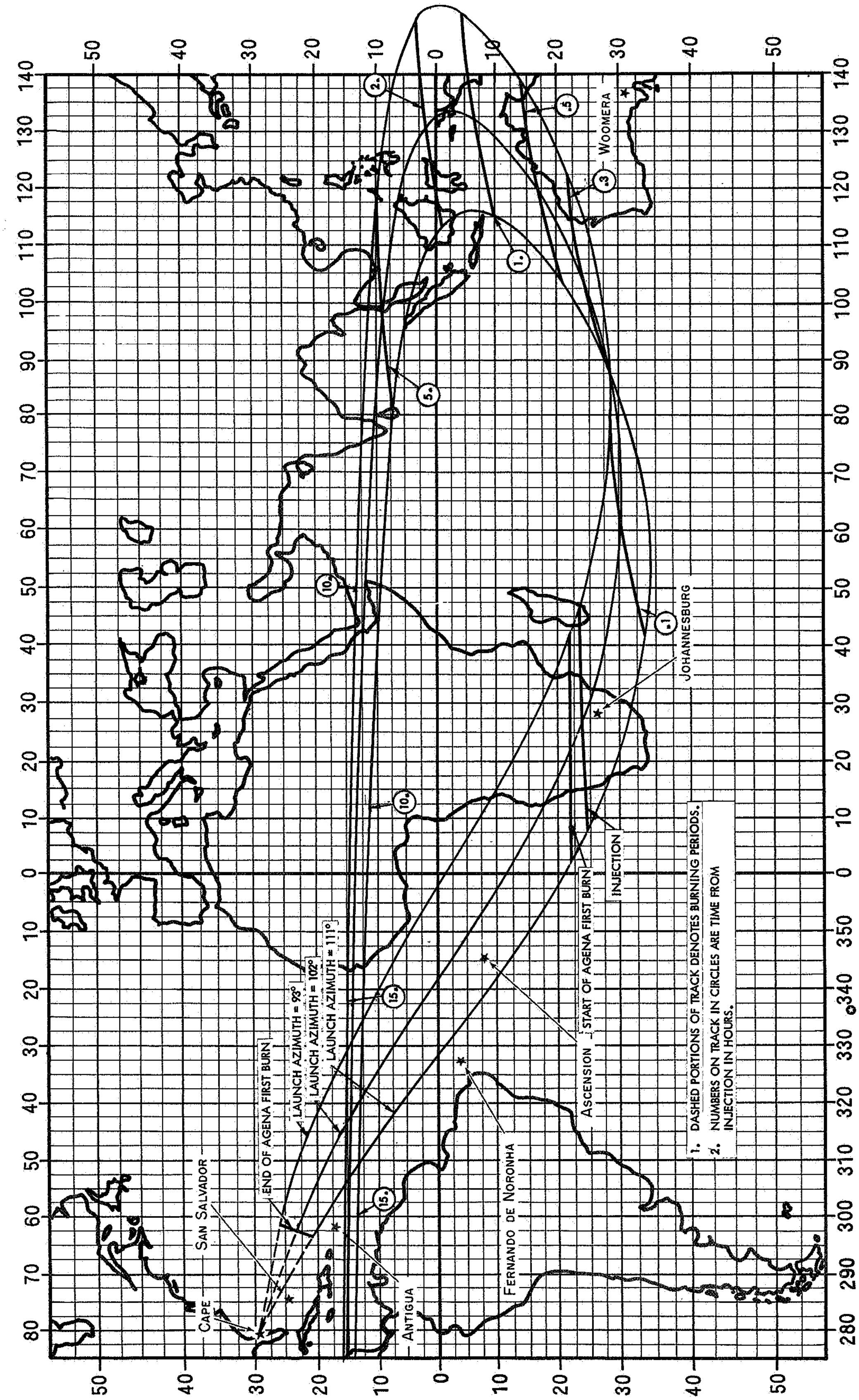


Figure 7. Earth Track Second Day Launch

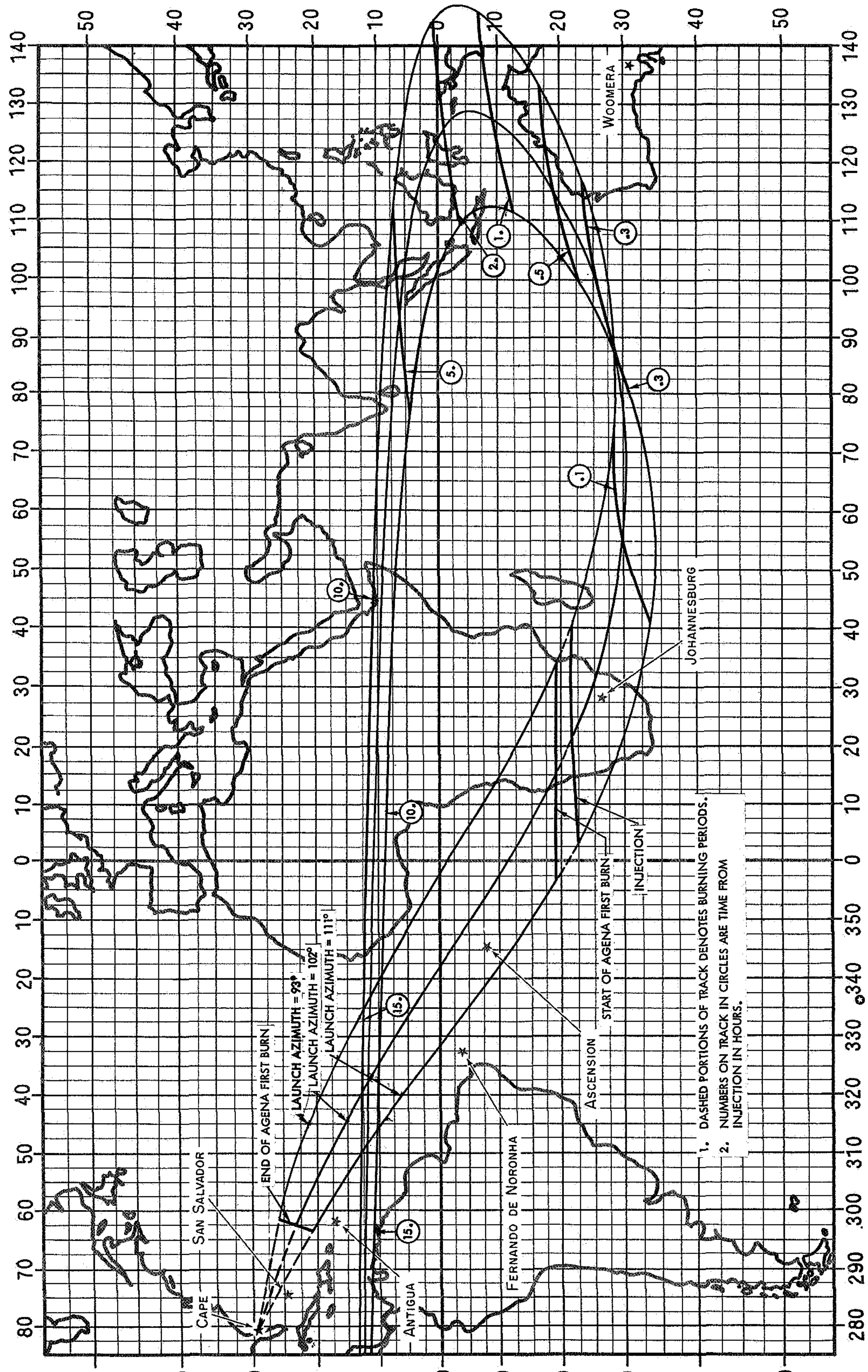


Figure 8. Earth Track Third Day Launch

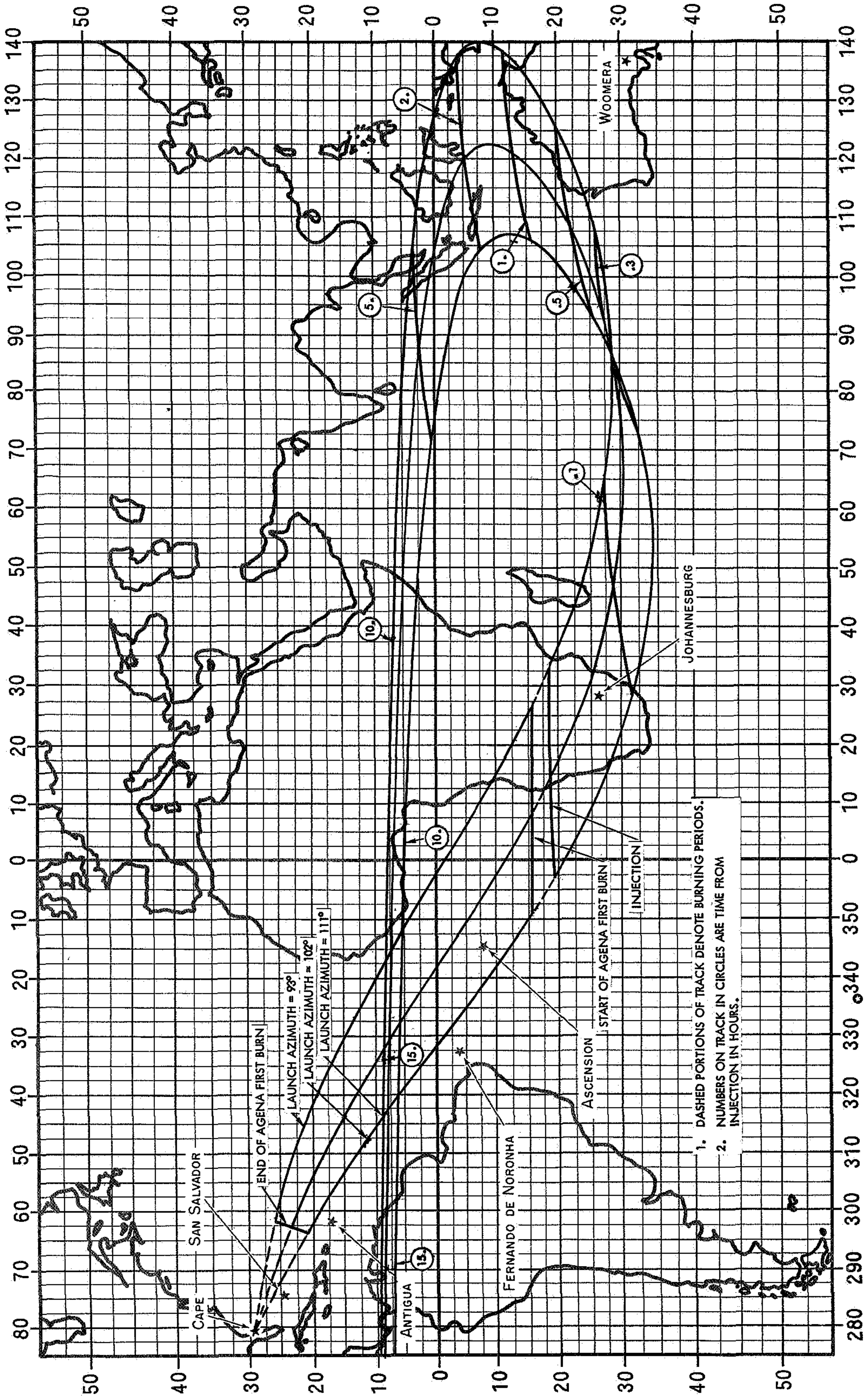


Figure 9. Earth Track Fourth Day Launch

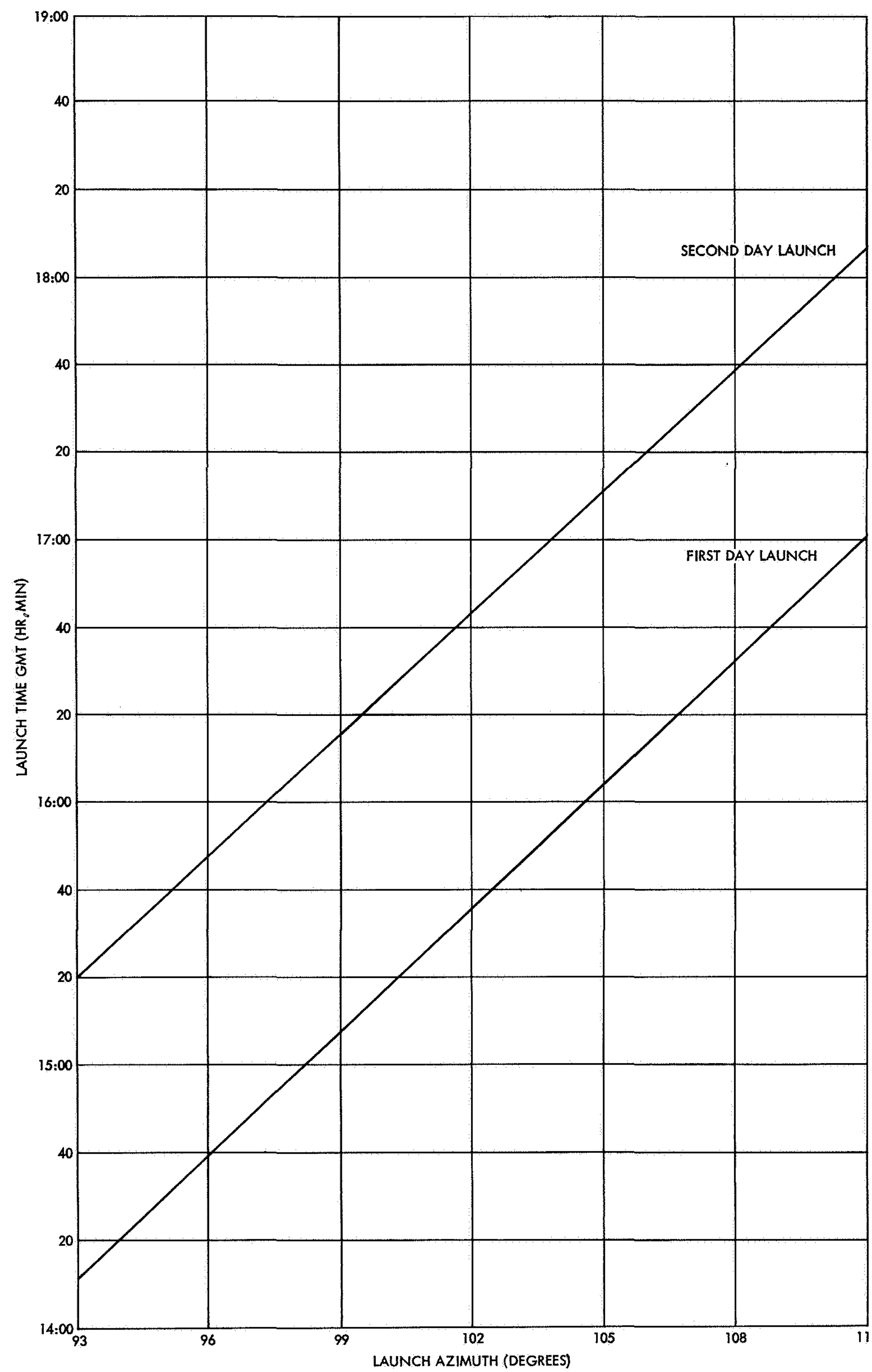


Figure 10. Launch Time vs Launch Azimuth

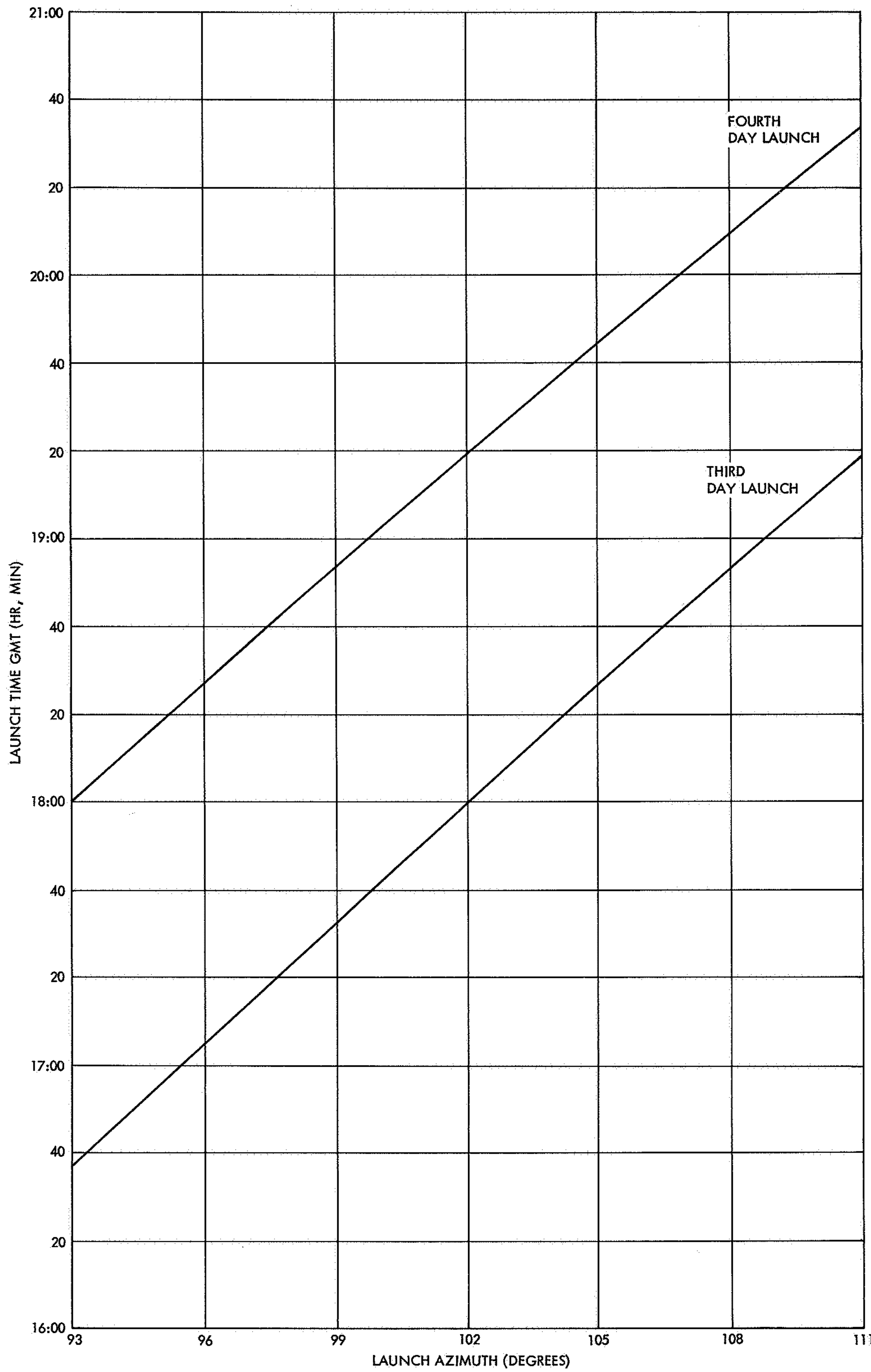


Figure 11. Launch Time vs Launch Azimuth

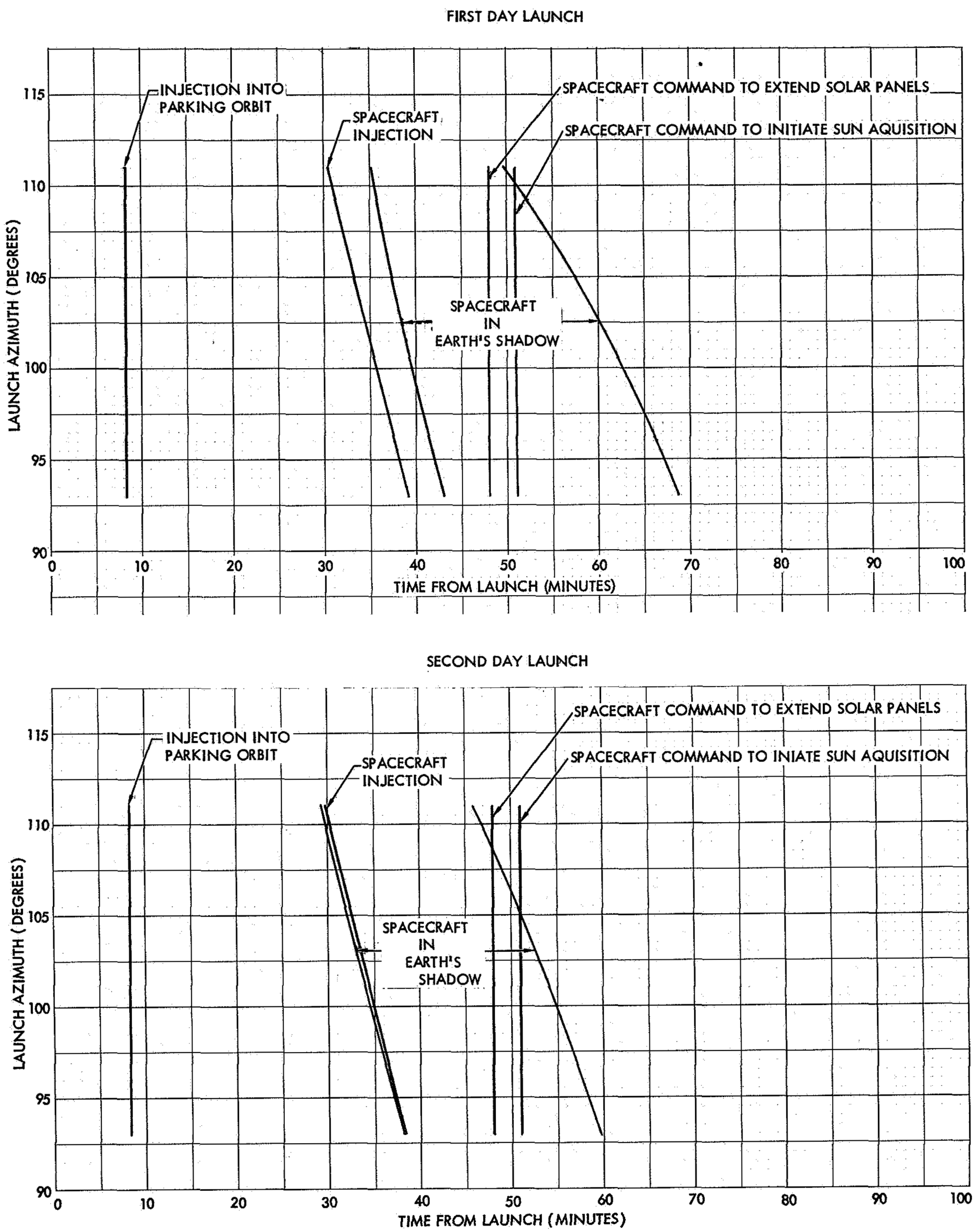
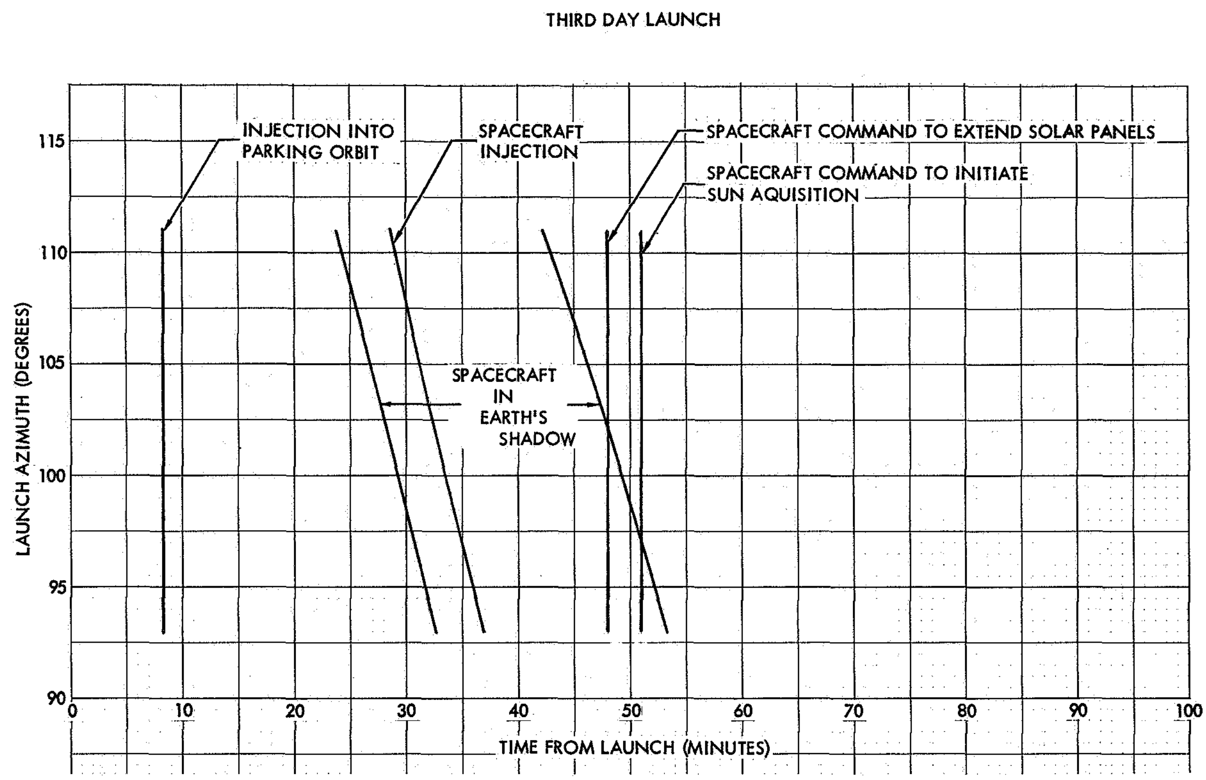


Figure 12. Time-From-Launch of Spacecraft Events vs Launch Azimuth for First Two Launch Days



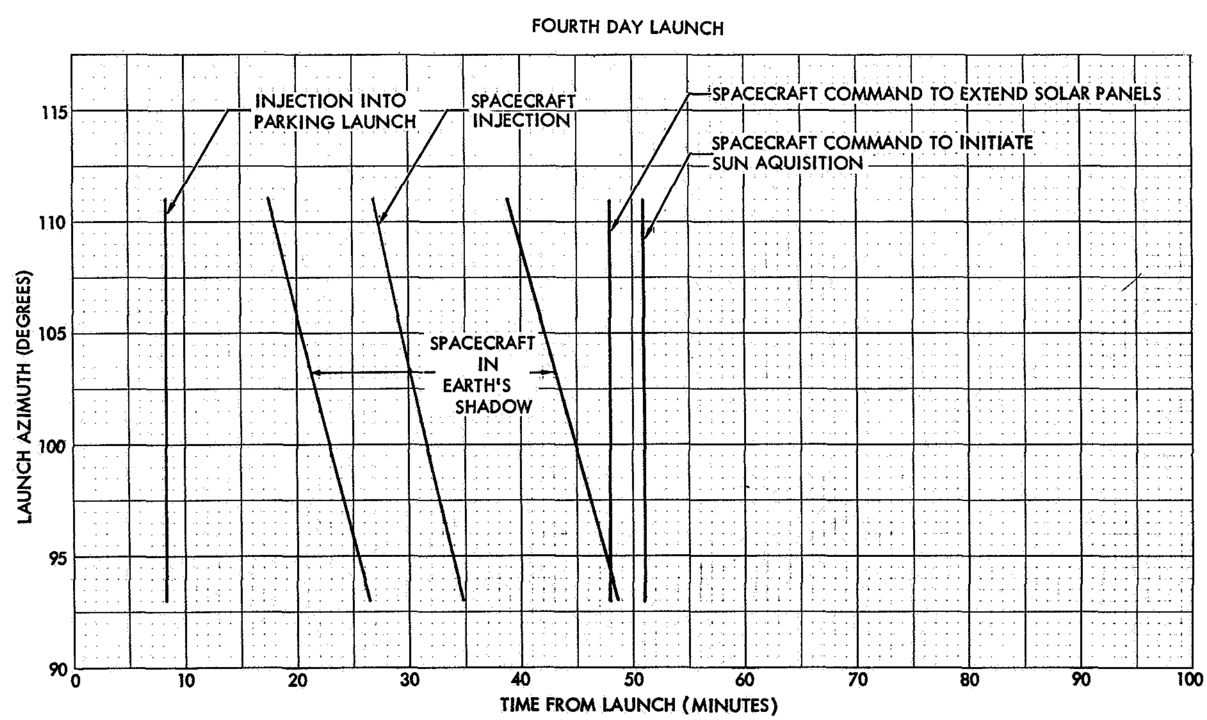


Figure 13. Time-From-Launch of Spacecraft Events vs Launch Azimuth for Last Two Launch Days

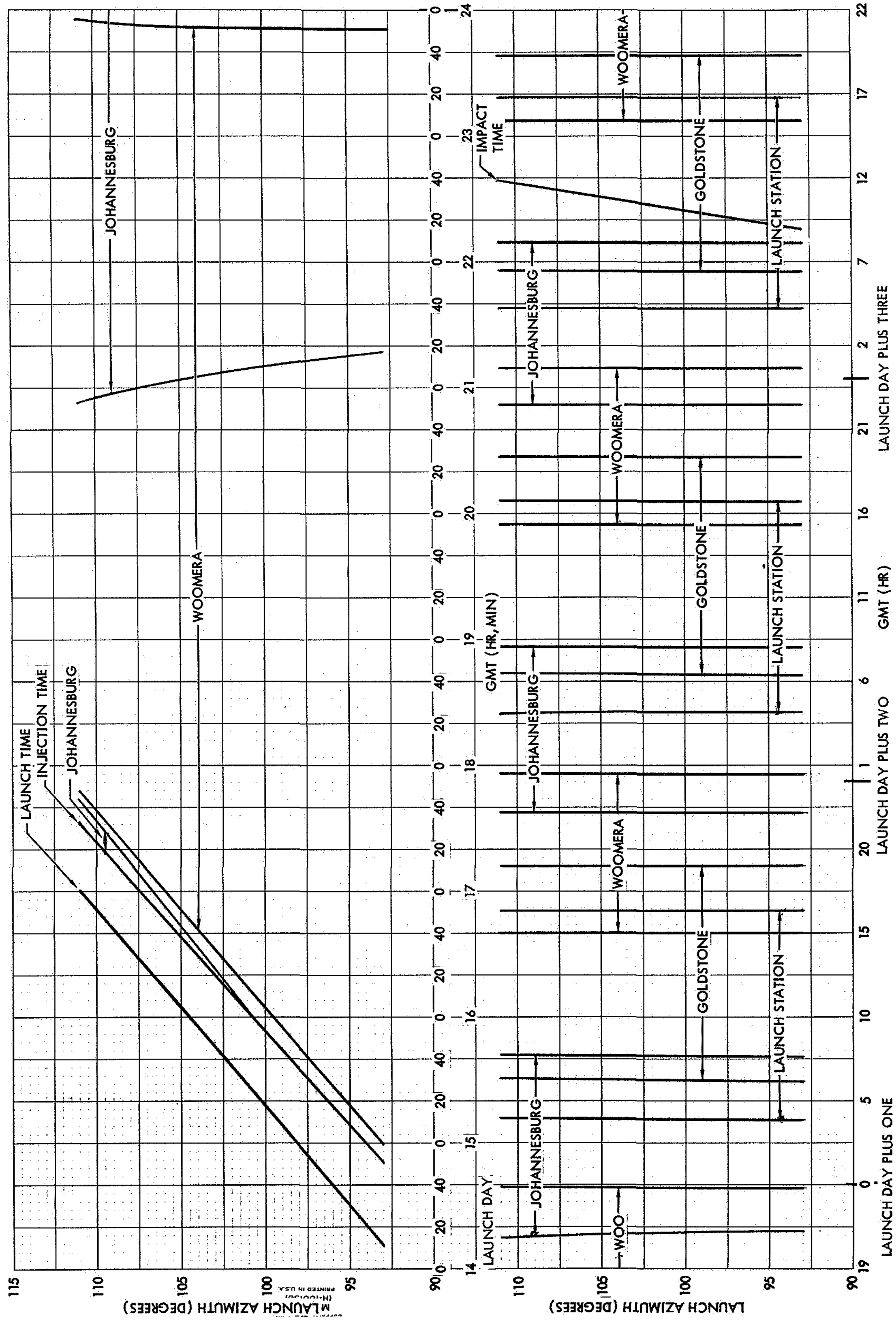


Figure 14. First Launch Day, Launch, Injection and Impact Times in GMT and Station Viewing Periods in GMT vs Launch Azimuth - RA-5 Trajectories

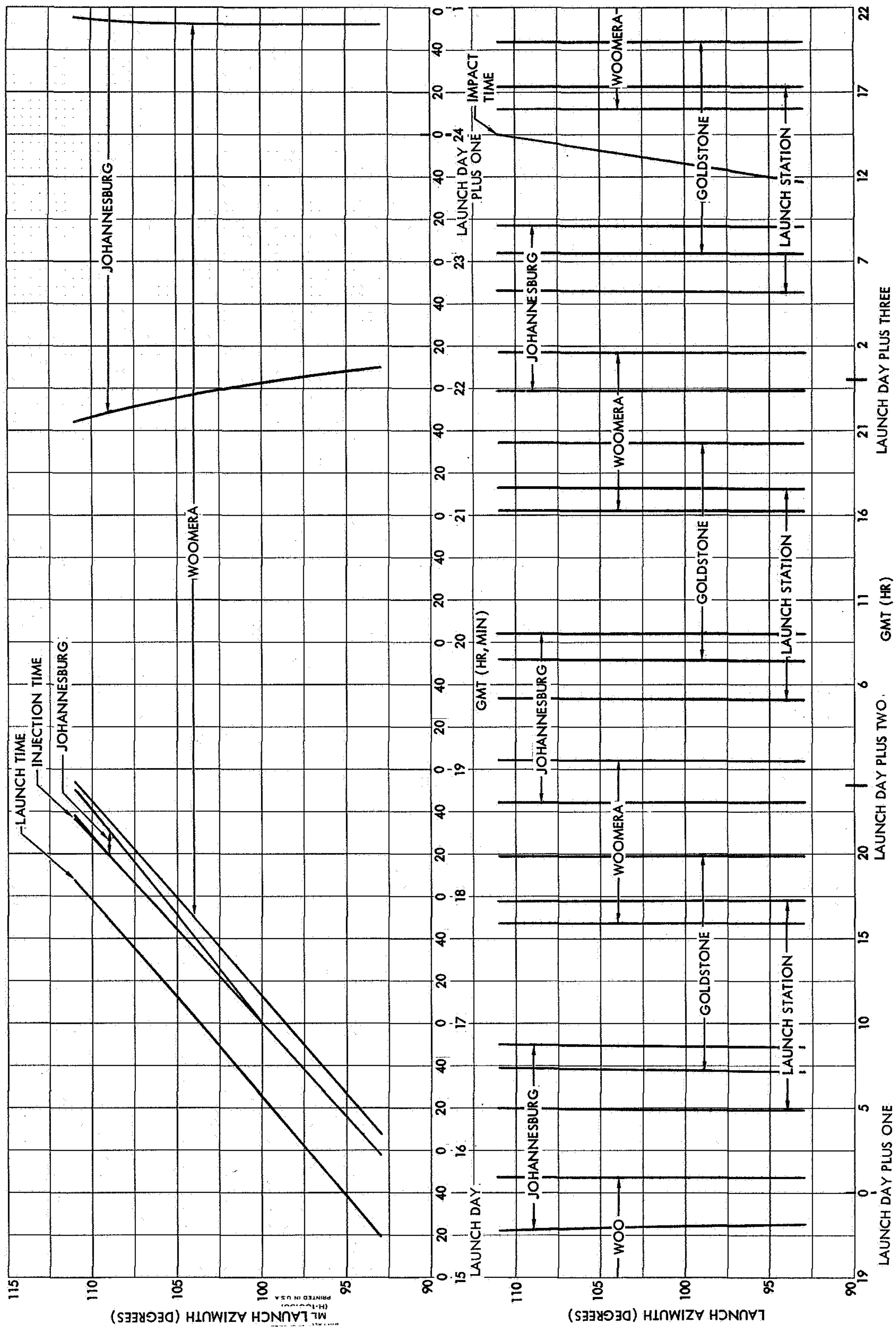


Figure 15. Second Launch Day, Launch, Injection and Impact Times in GMT and Station Viewing Periods in GMT vs Launch Azimuth - RA-5 Trajectories

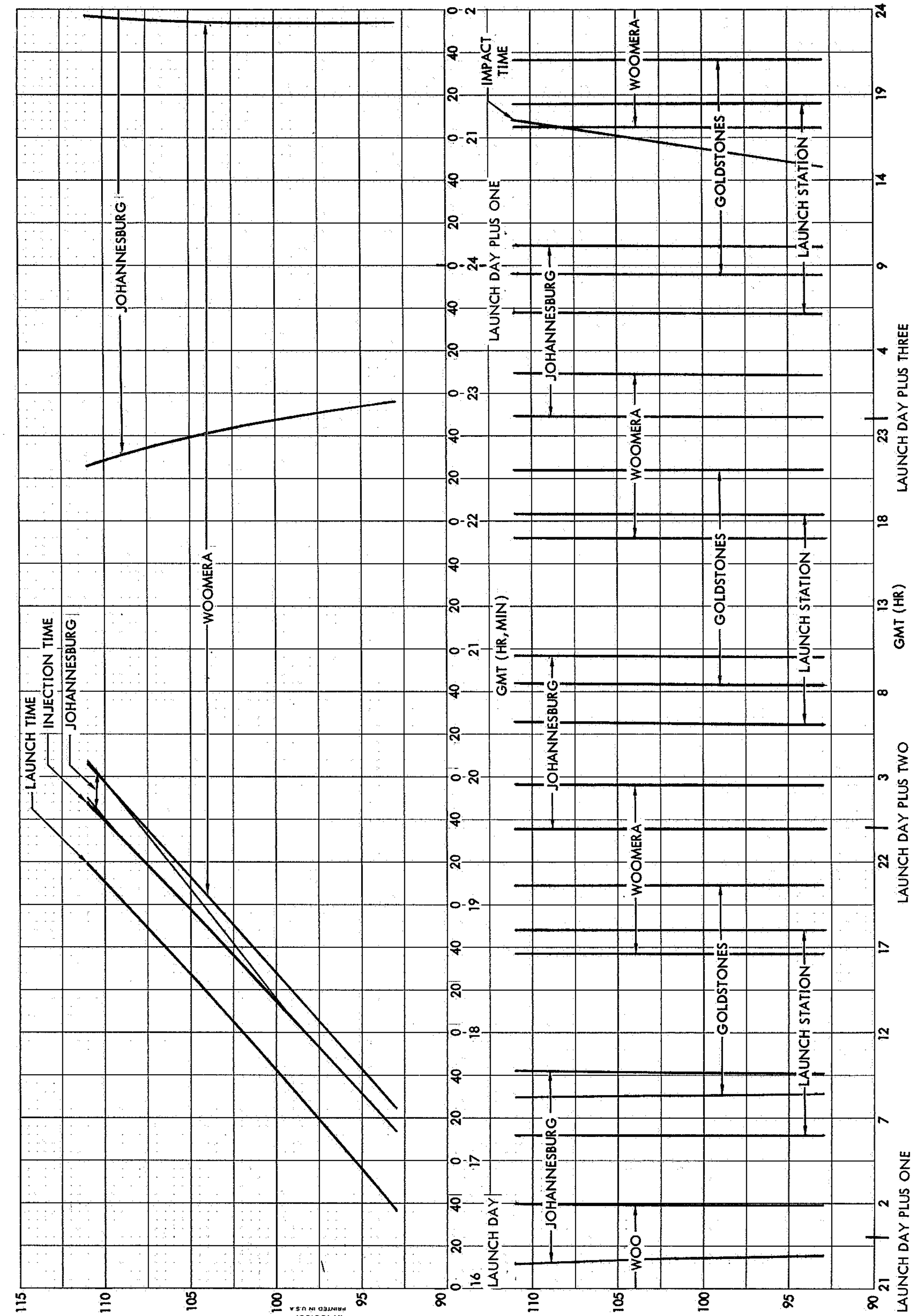


Figure 16. Third Launch Day, Launch, Injection and Impact Times in GMT and Station Viewing Periods in GMT vs Launch Azimuth - RA-5 Trajectories

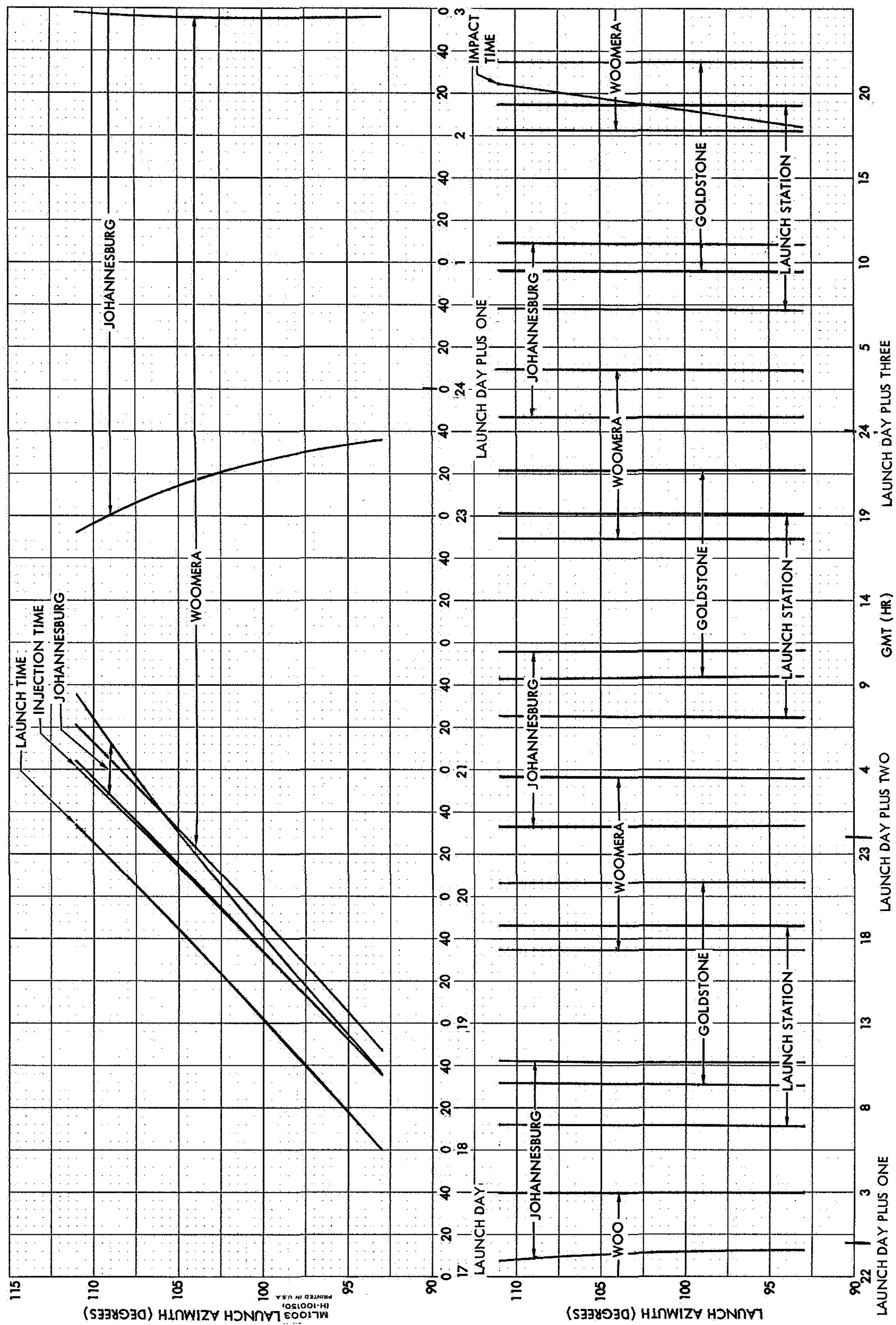


Figure 17. Fourth Launch Day, Launch, Injection and Impact Times in GMT and Station Viewing Periods in GMT vs Launch Azimuth - RA-5 Trajectories

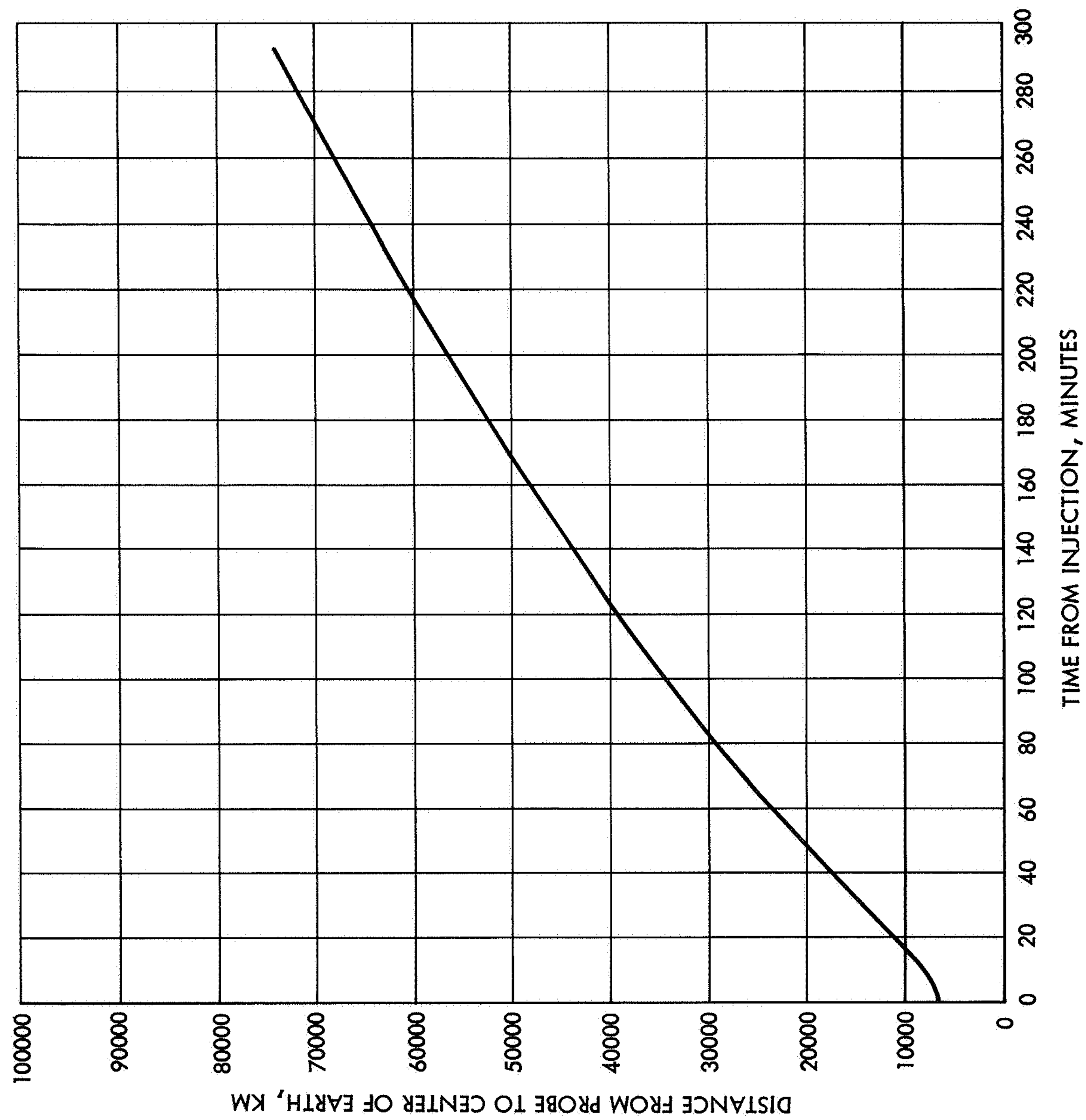


Figure 18. Distance from Probe to Center of Earth vs Time from Injection in Minutes, Launch Azimuth 102 Degrees

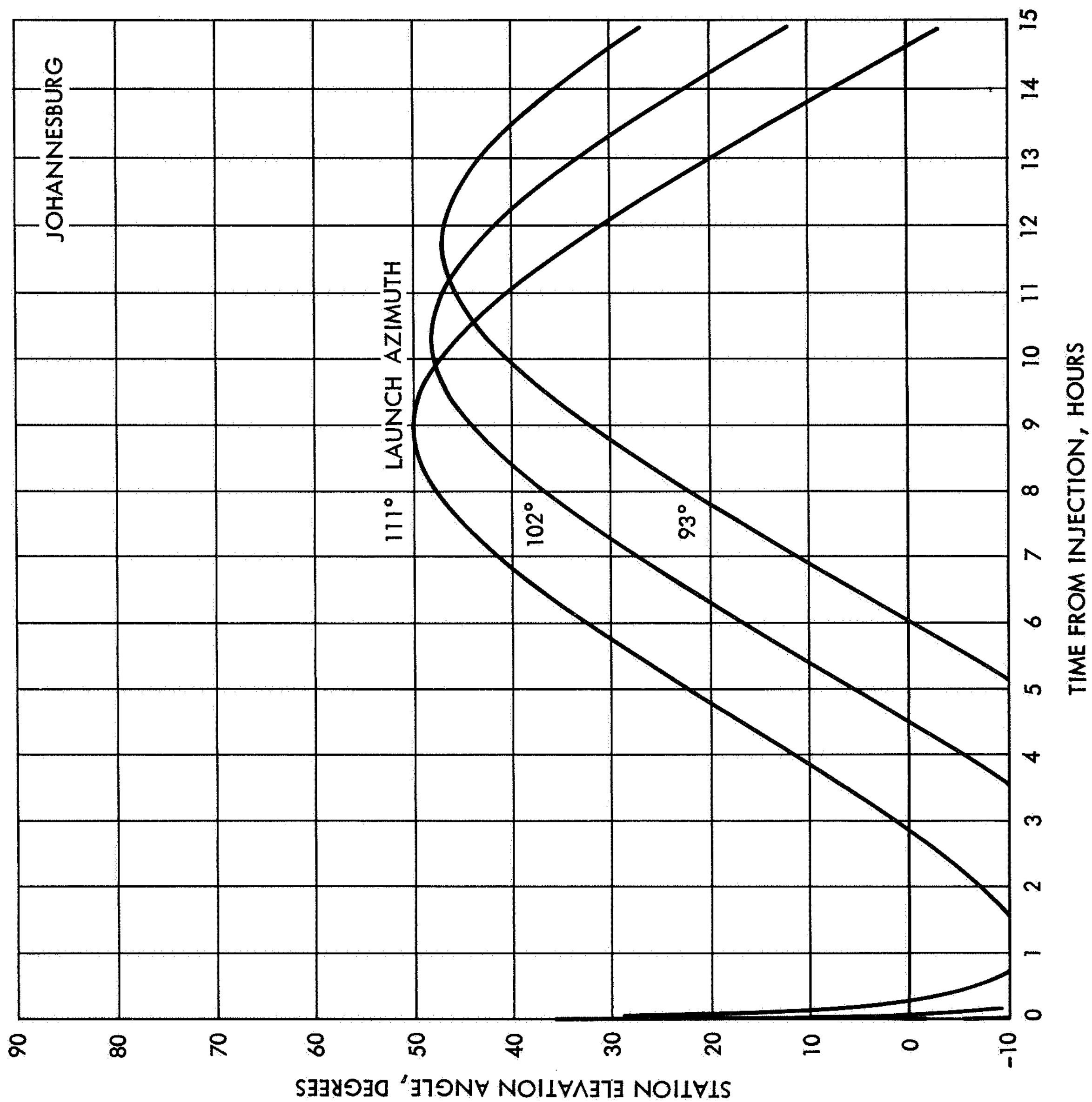


Figure 19. First Day Launch. Station Elevation Angle vs Time Past Injection for First Fifteen Hours

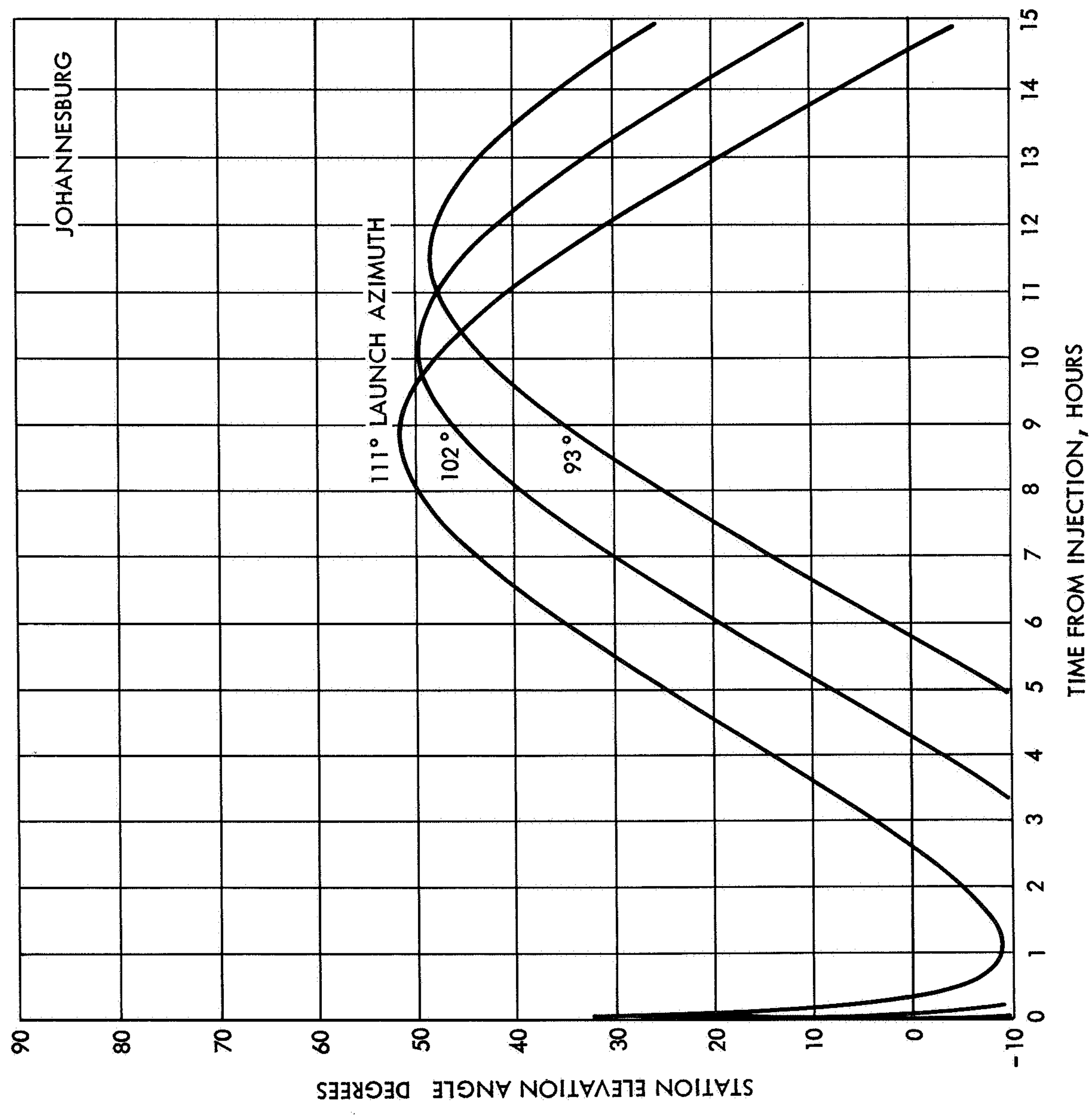


Figure 20. Second Day Launch Station Elevation Angle vs Time Past Injection for First Fifteen Hours

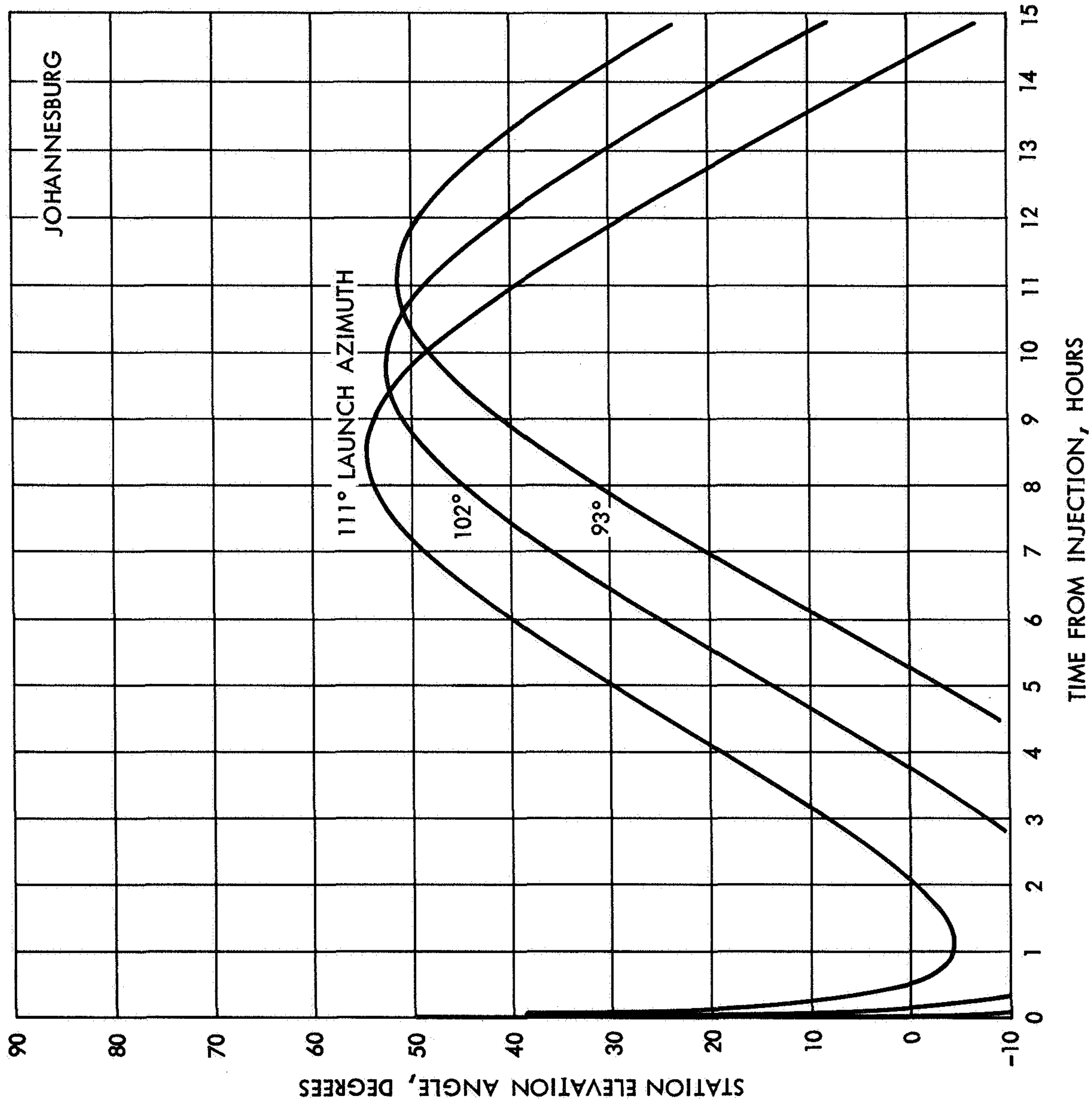


Figure 21. Third Day Launch Station Elevation Angle vs Time Past Injection for First Fifteen Hours

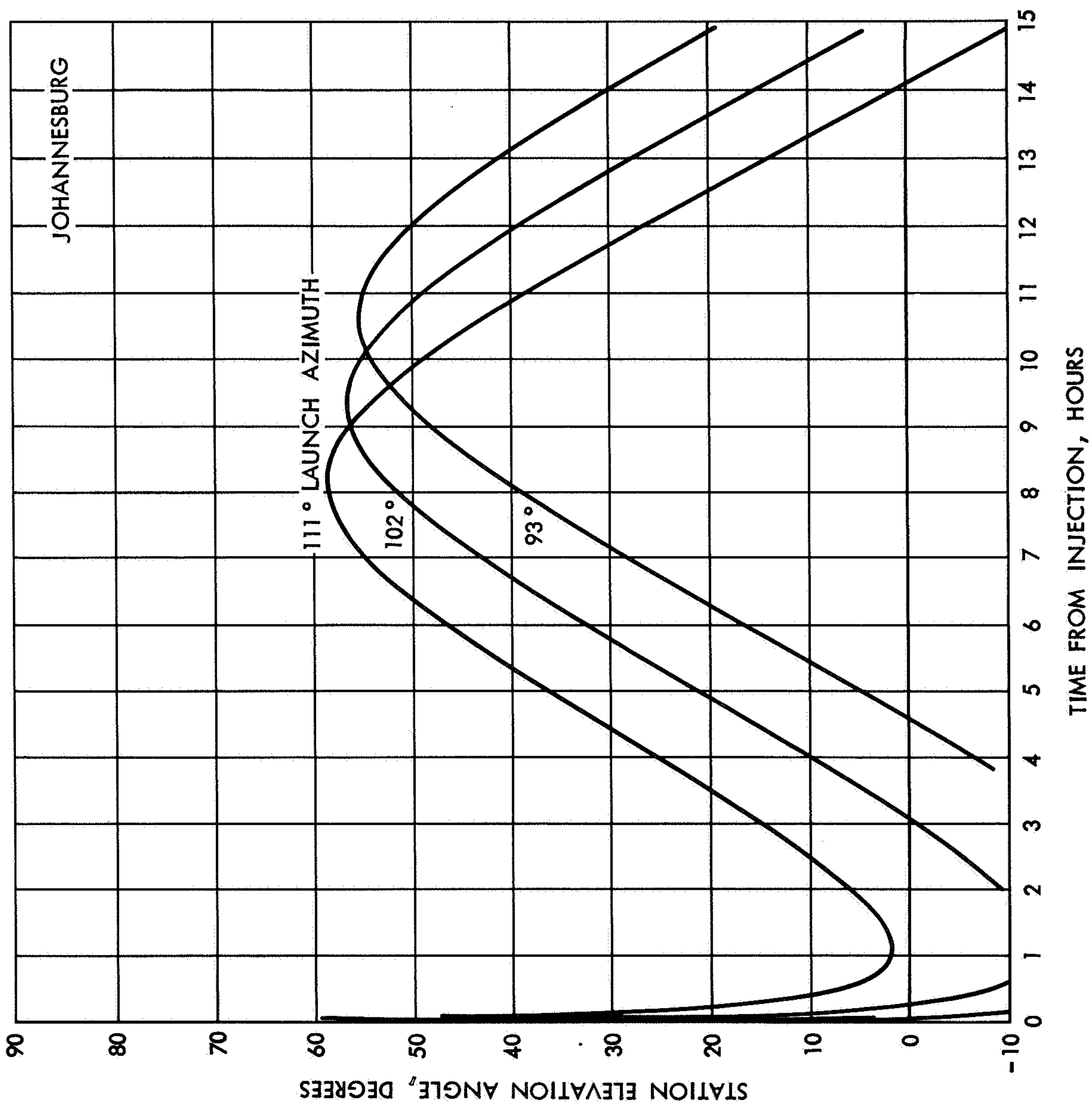


Figure 22 Fourth Day Launch, Station Elevation Angle vs Time Past Injection for Fifteen Hours

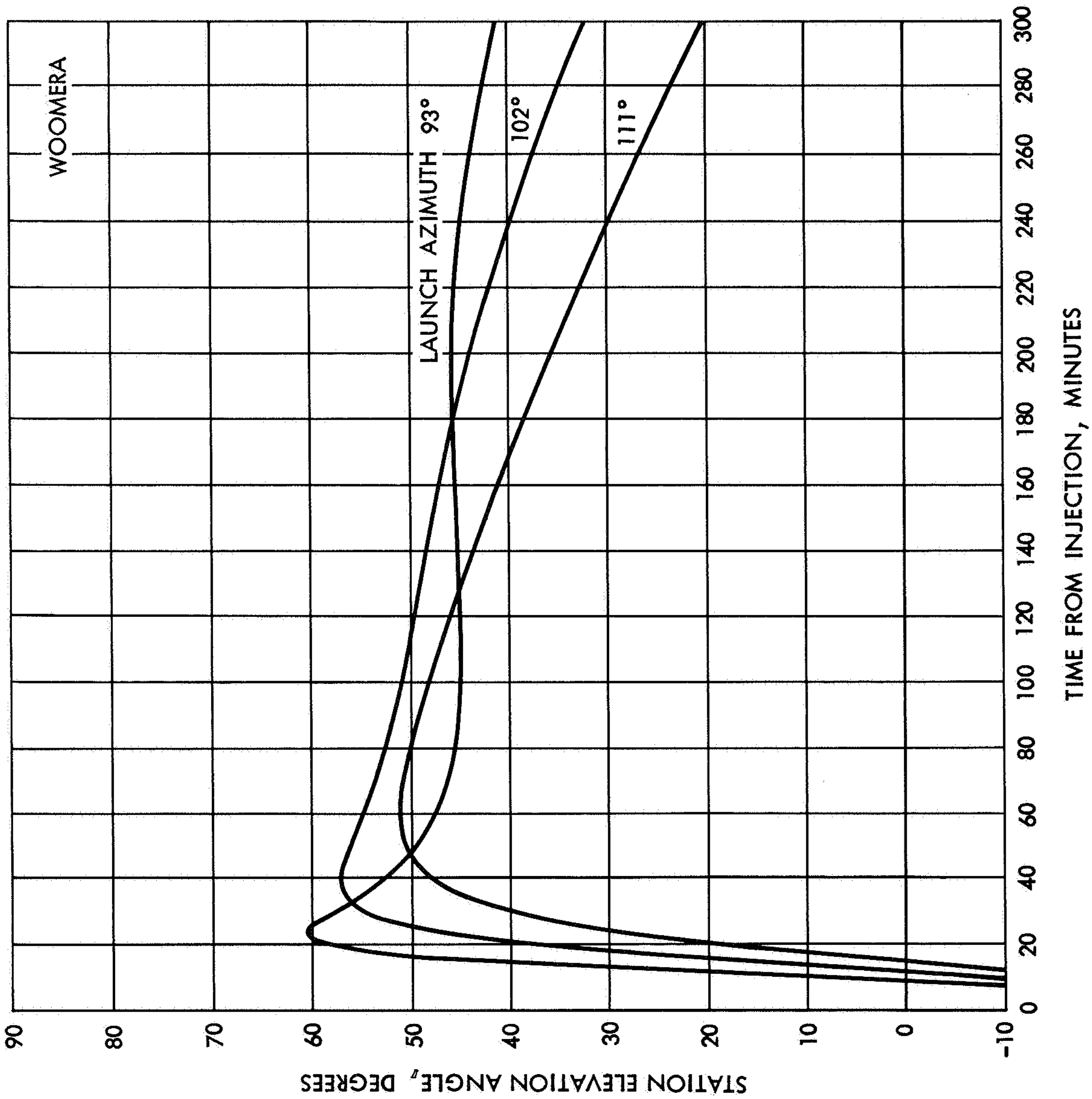


Figure 23. First Day Launch, Station Elevation Angle vs Time Past Injection for First Five Hours

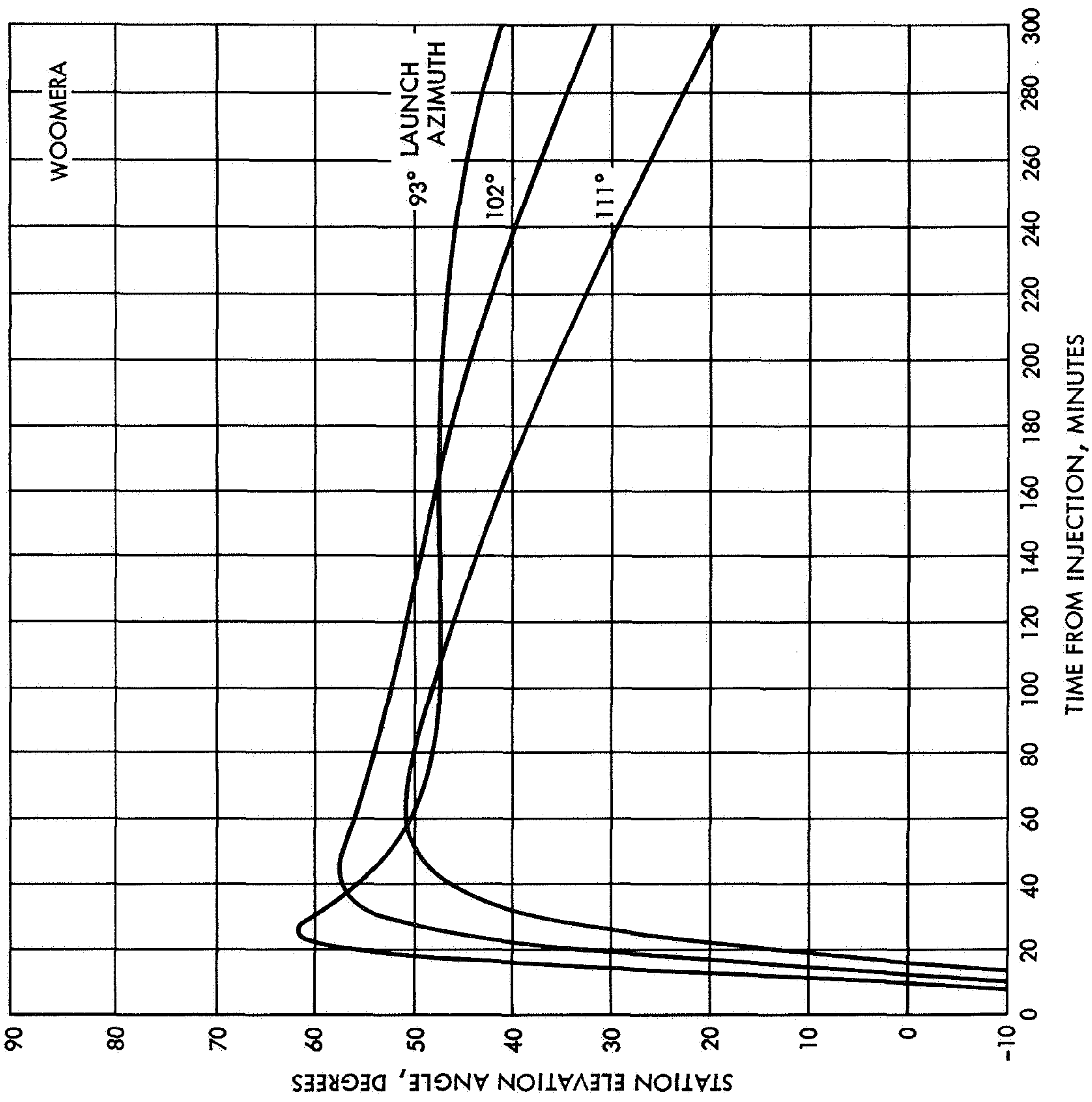


Figure 24. Second Day Launch, Station Elevation Angle vs Time Past Injection for First Five Hours

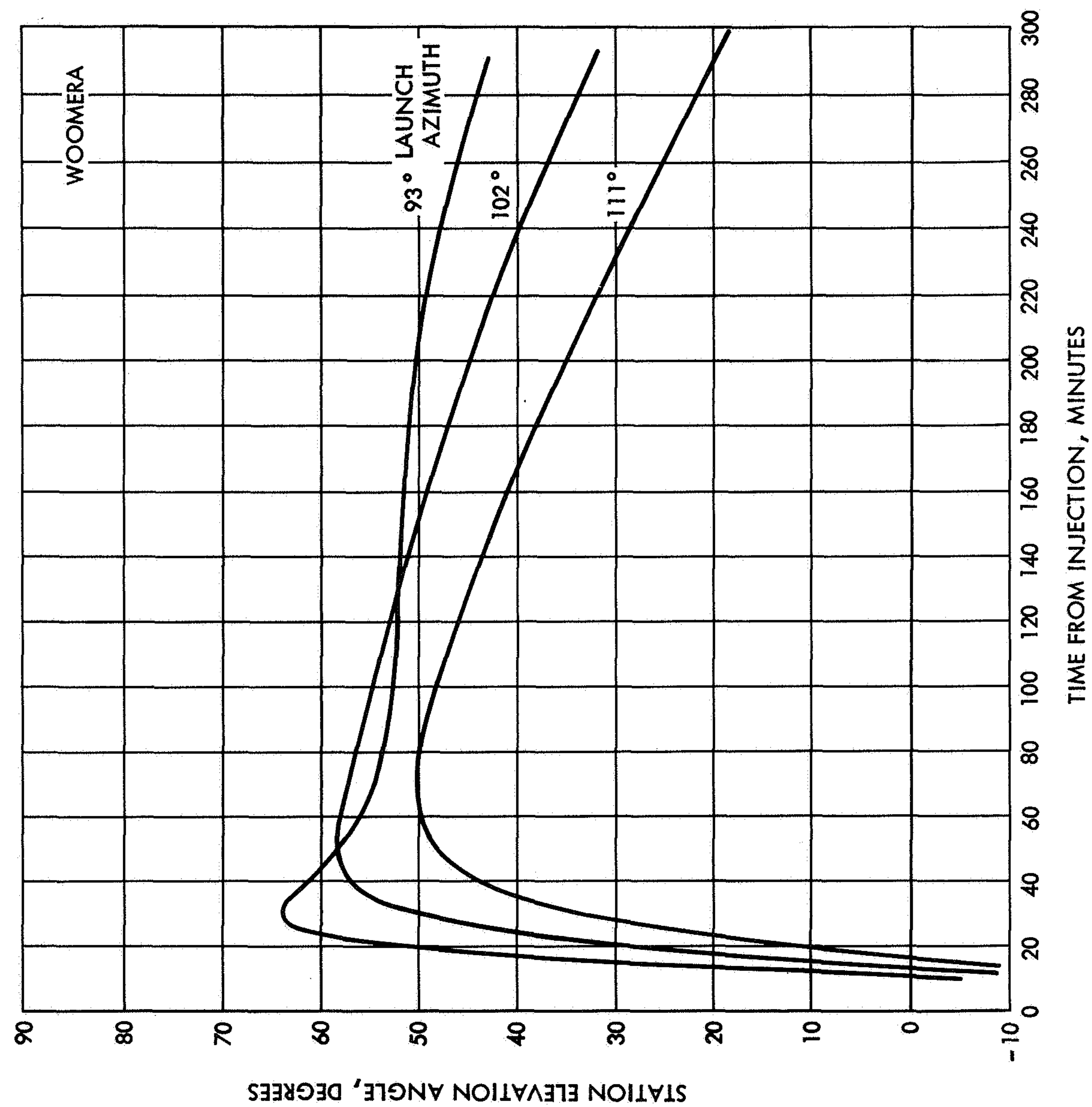


Figure 25. Third Day Launch, Station Elevation Angle vs Time Past Injection for First Five Hours

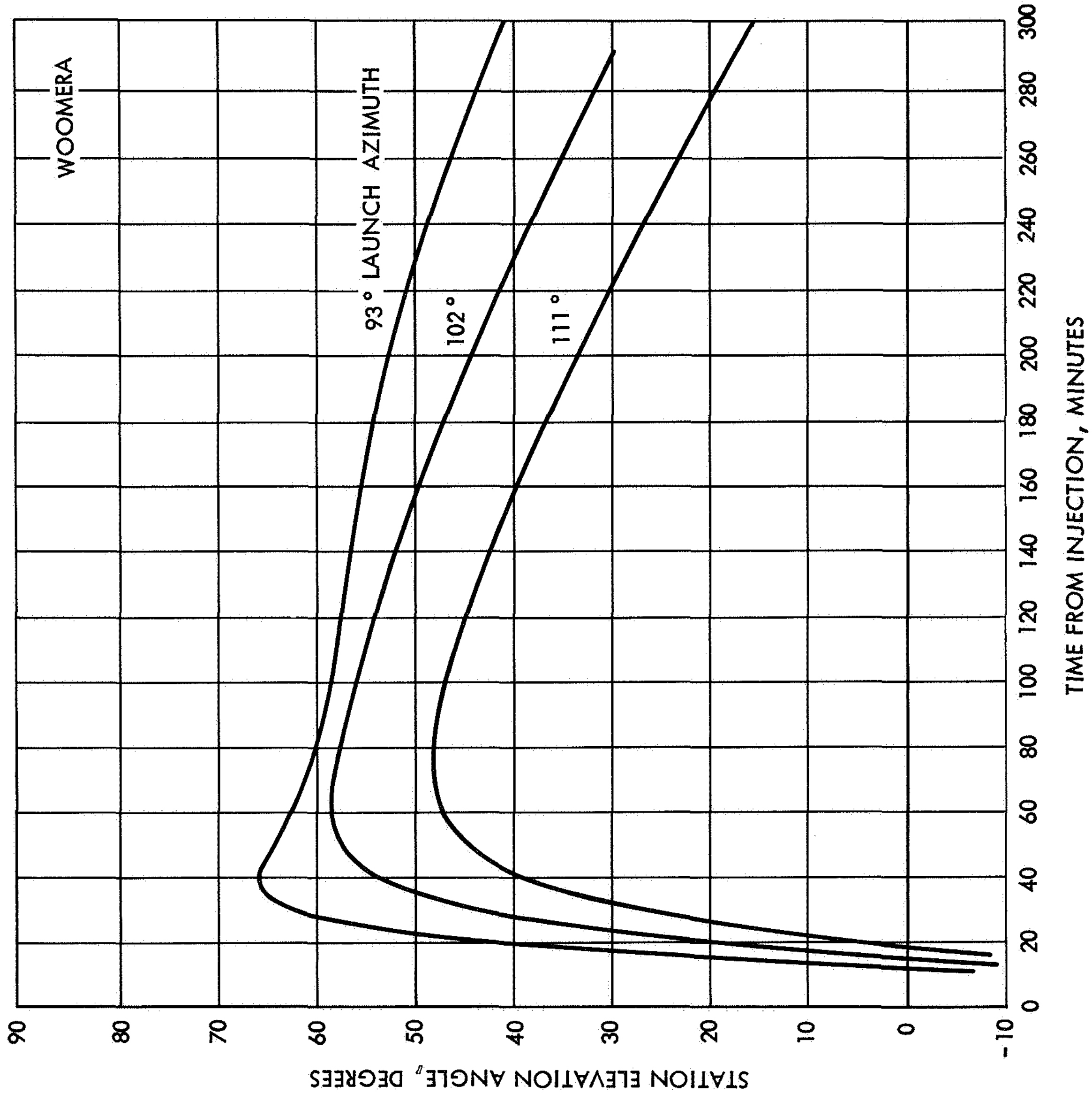


Figure 26. Fourth Day Launch, Station Elevation Angle vs Time Past Injection for First Five Hours

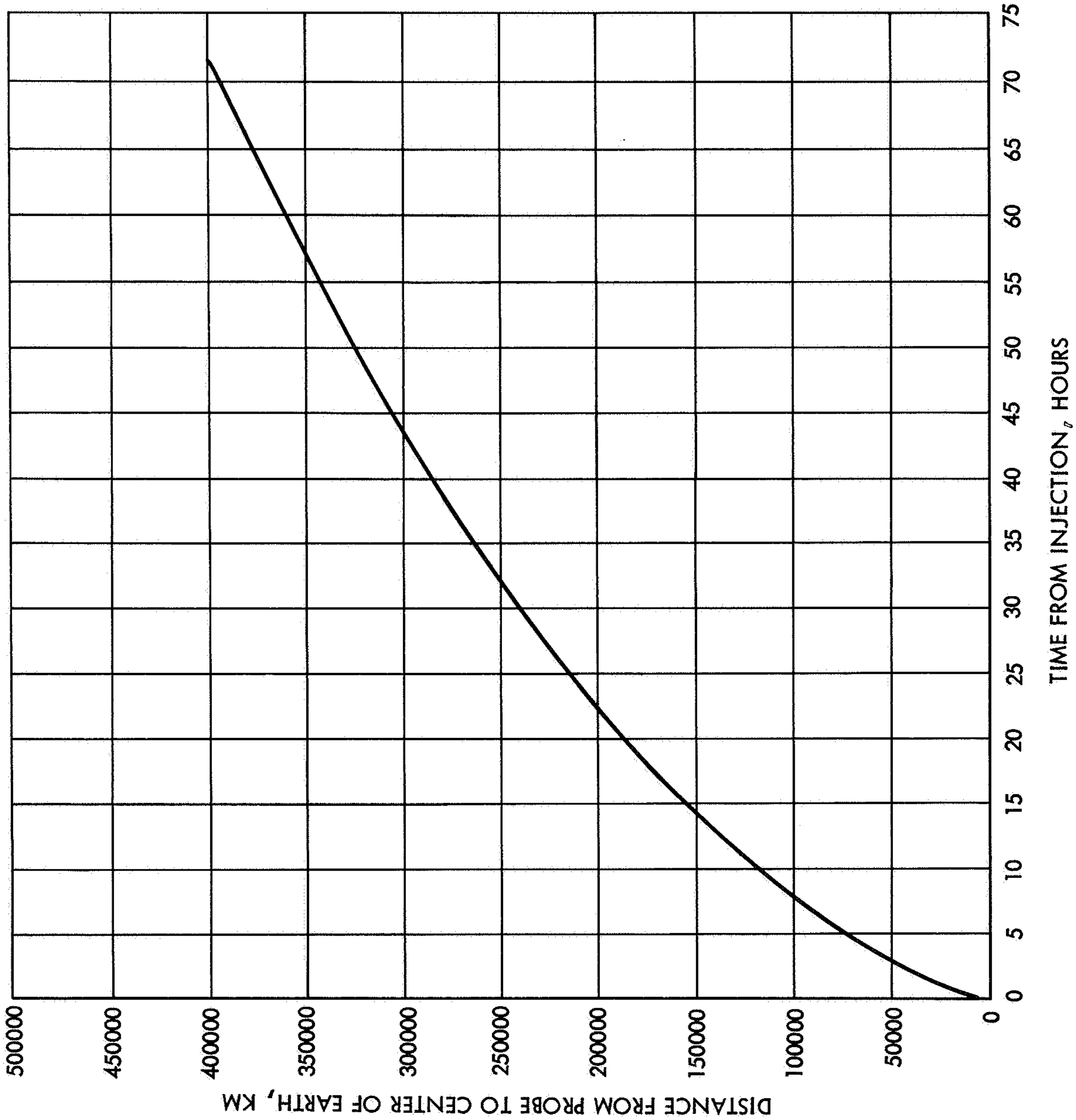


Figure 27. Distance from Probe to Center of Earth vs Time After Injection in Hours, Launch Azimuth 102 Degrees

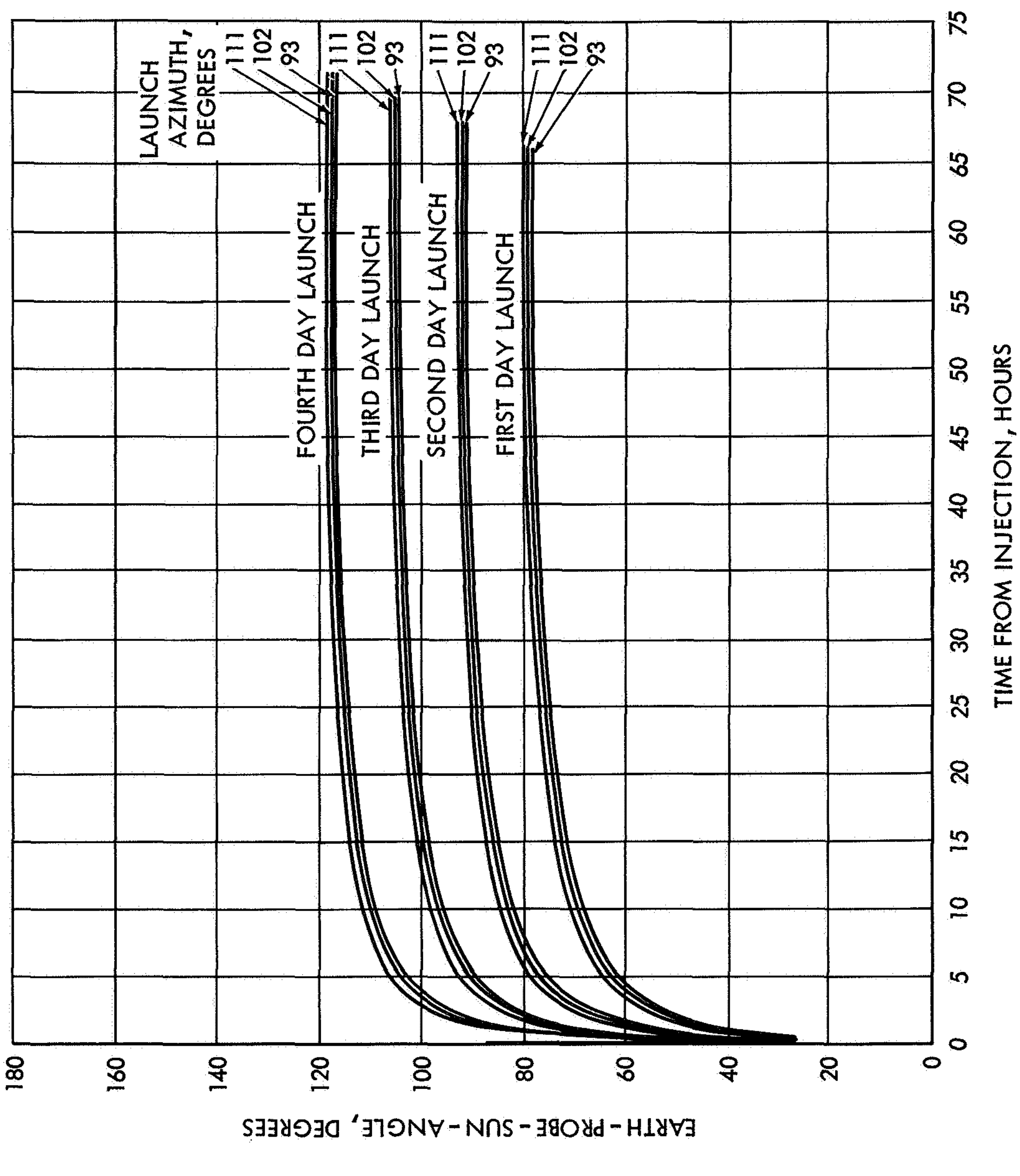


Figure 28. Earth-Probe-Sun Angle vs Time Past Injection in Hours

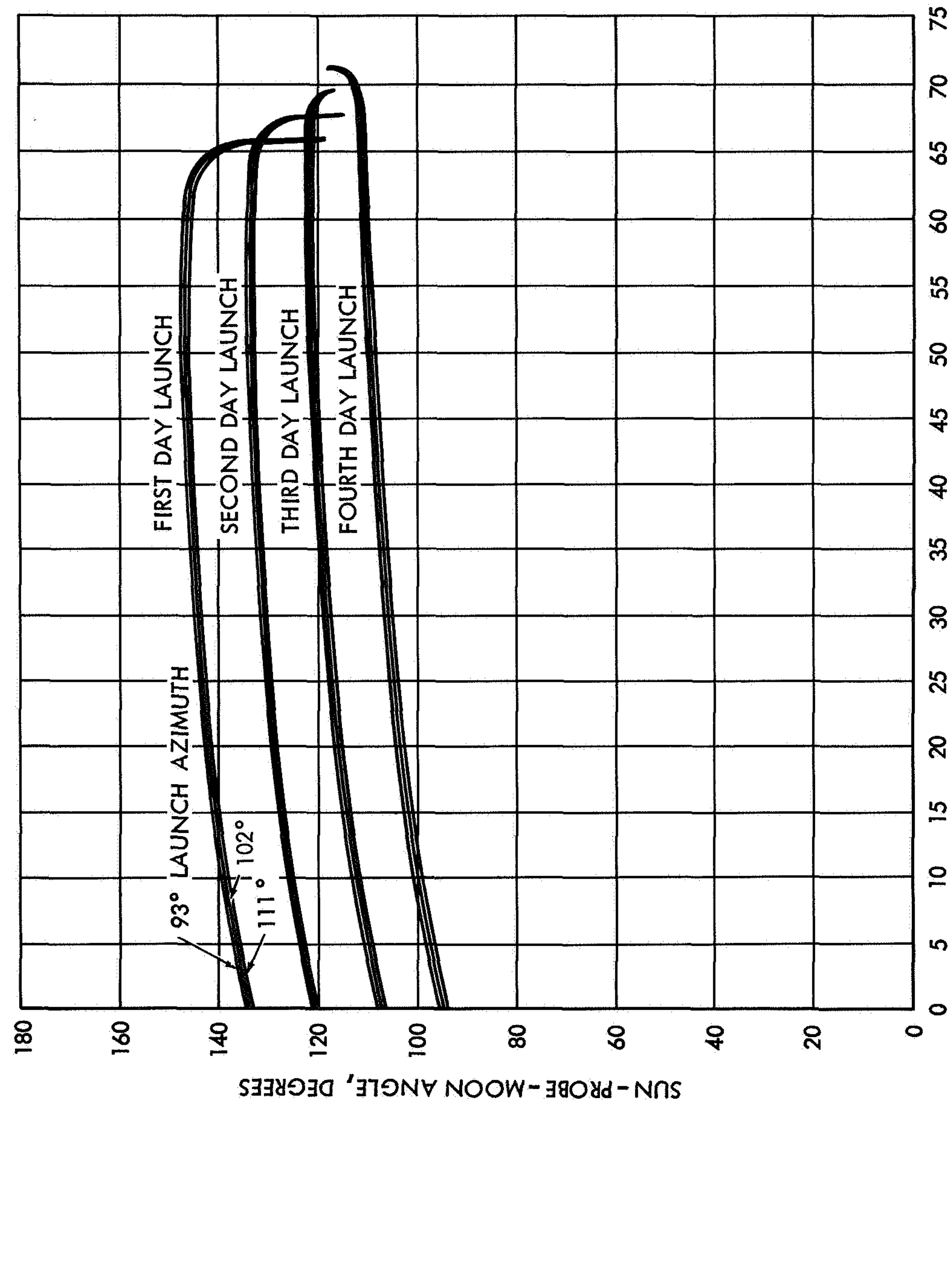


Figure 29. Sun-Probe-Moon Angle vs Time Past Injection in Hours

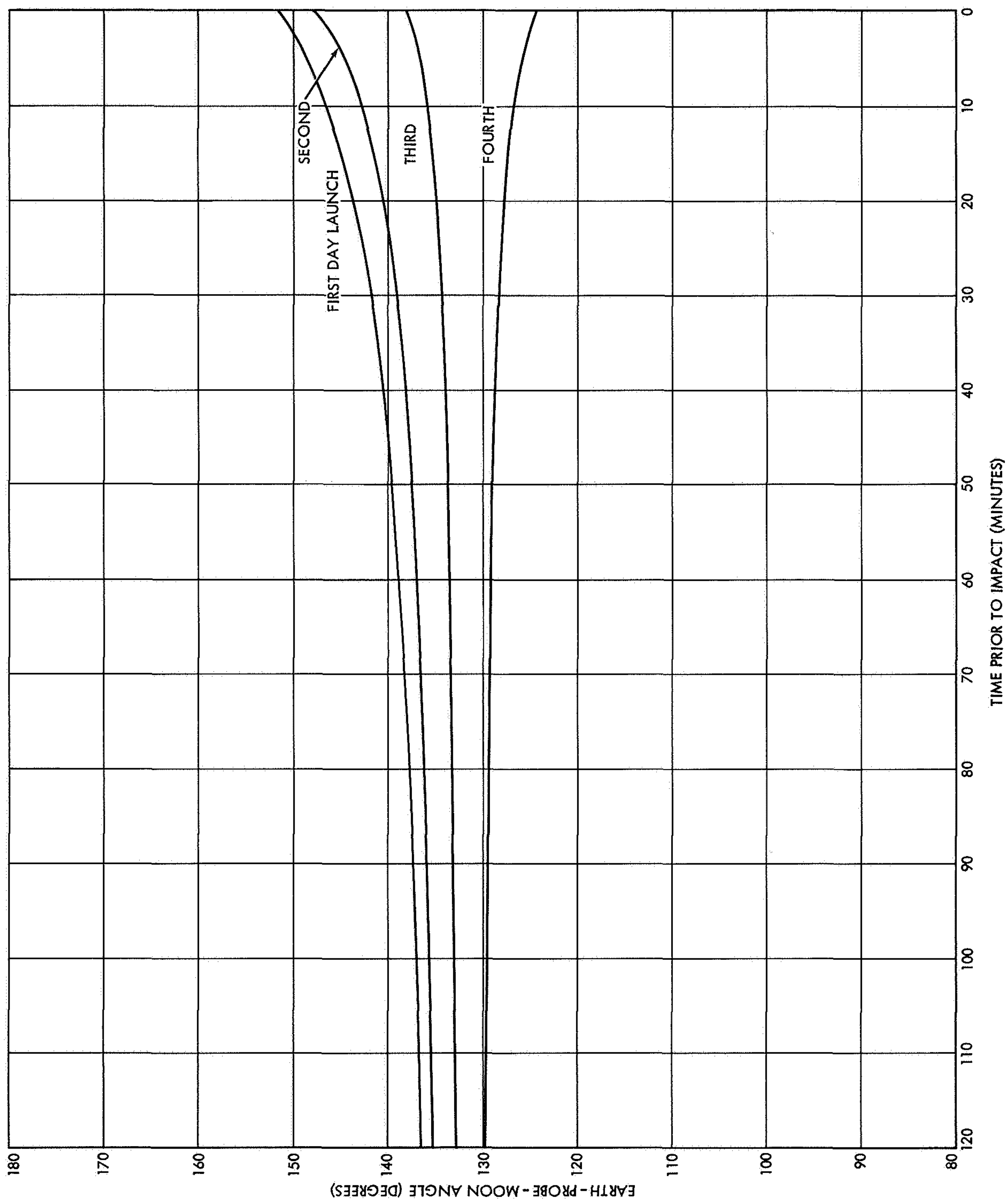


Figure 30. EARTH-PROBE-MOON ANGLE vs. Time Prior to Impact, Launch Azimuth 102 Degrees

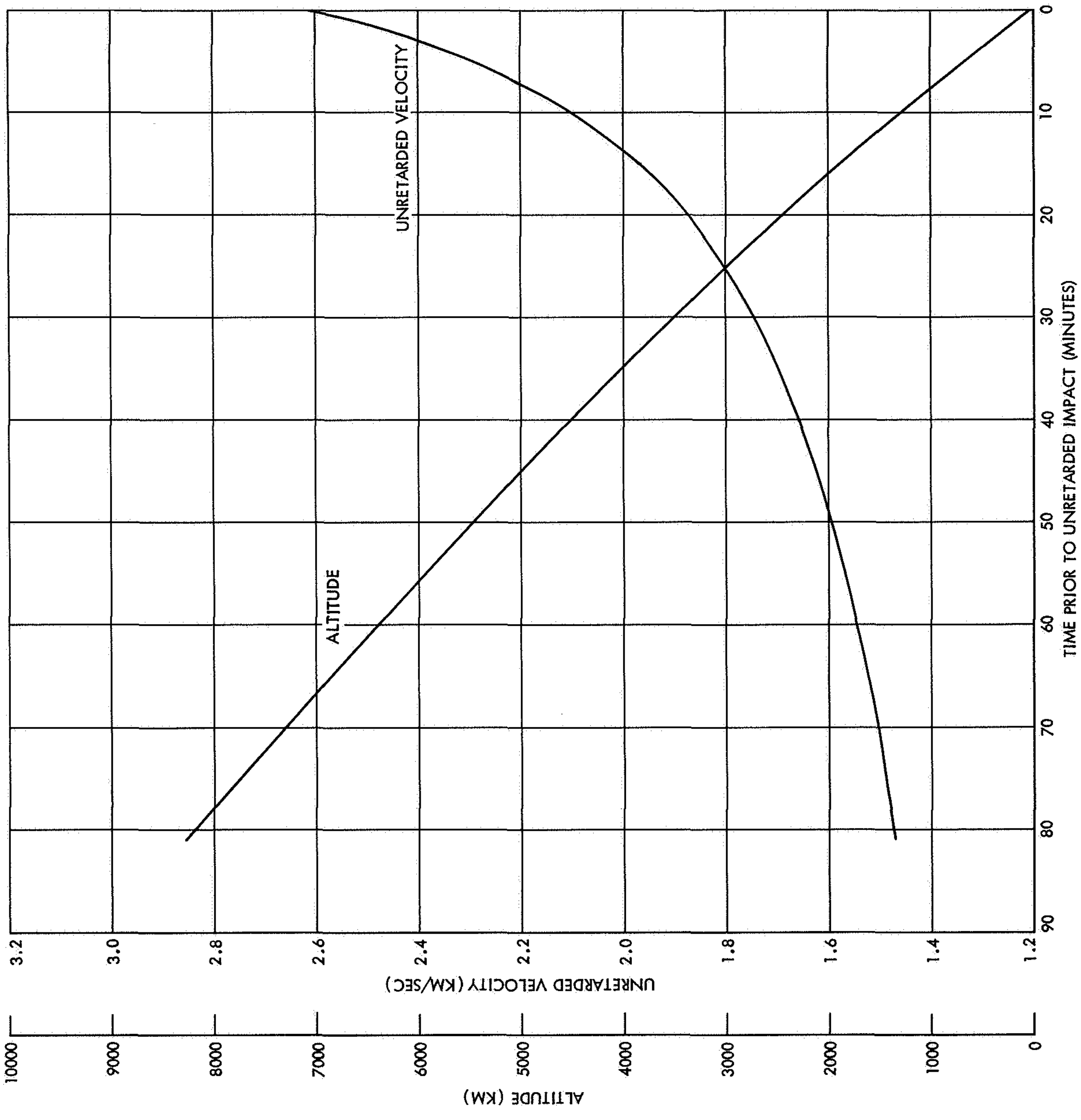


Figure 31. ALTITUDE and UNRETARDED VELOCITY vs. Time Prior to Unretarded Impact for Typical RA-5 Trajectory, Last Eighty Minutes

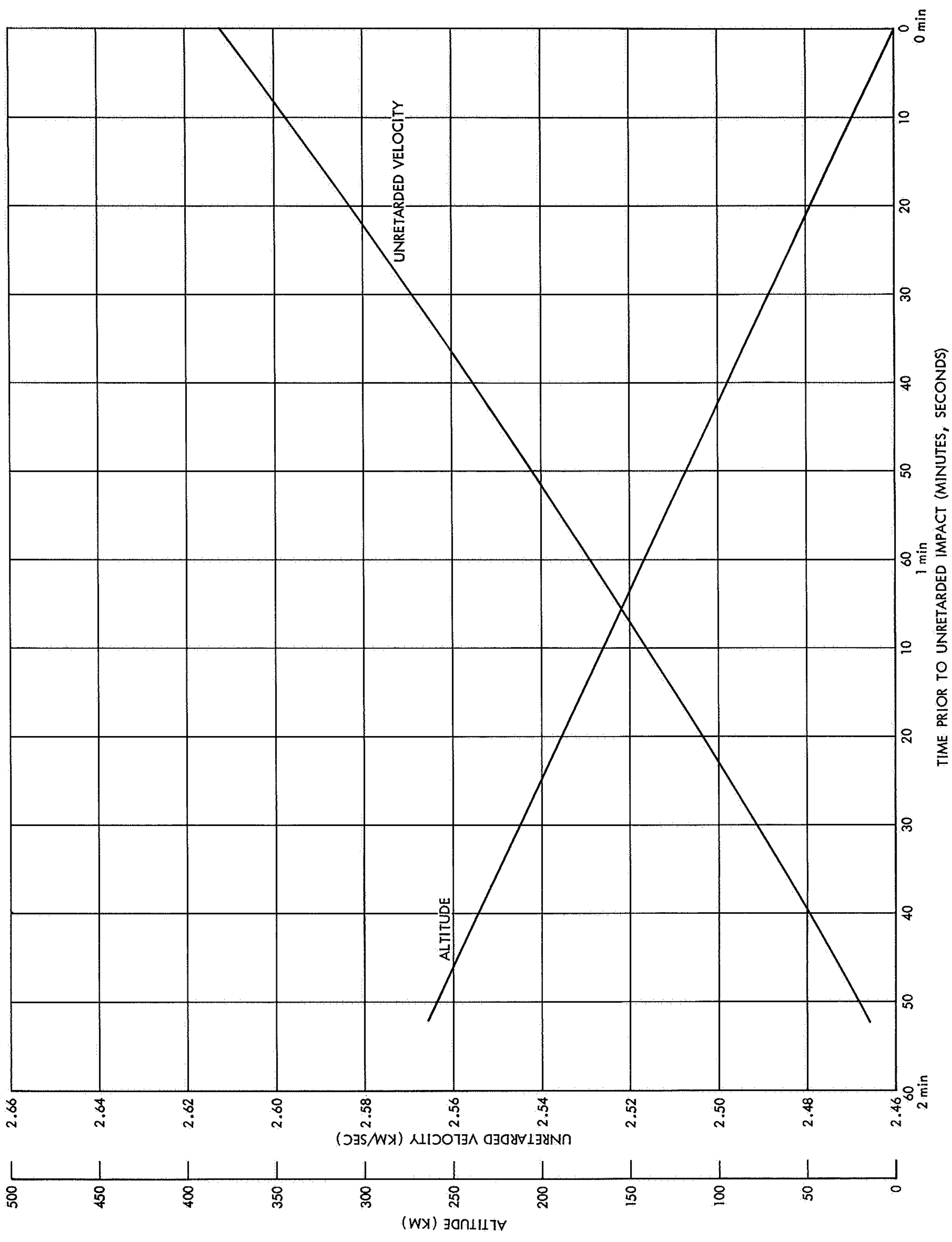


Figure 32. ALTITUDE and UNRETARDED VELOCITY vs. Time Prior to Unretarded Impact for Typical RA-5 Trajectory, Last Two Minutes

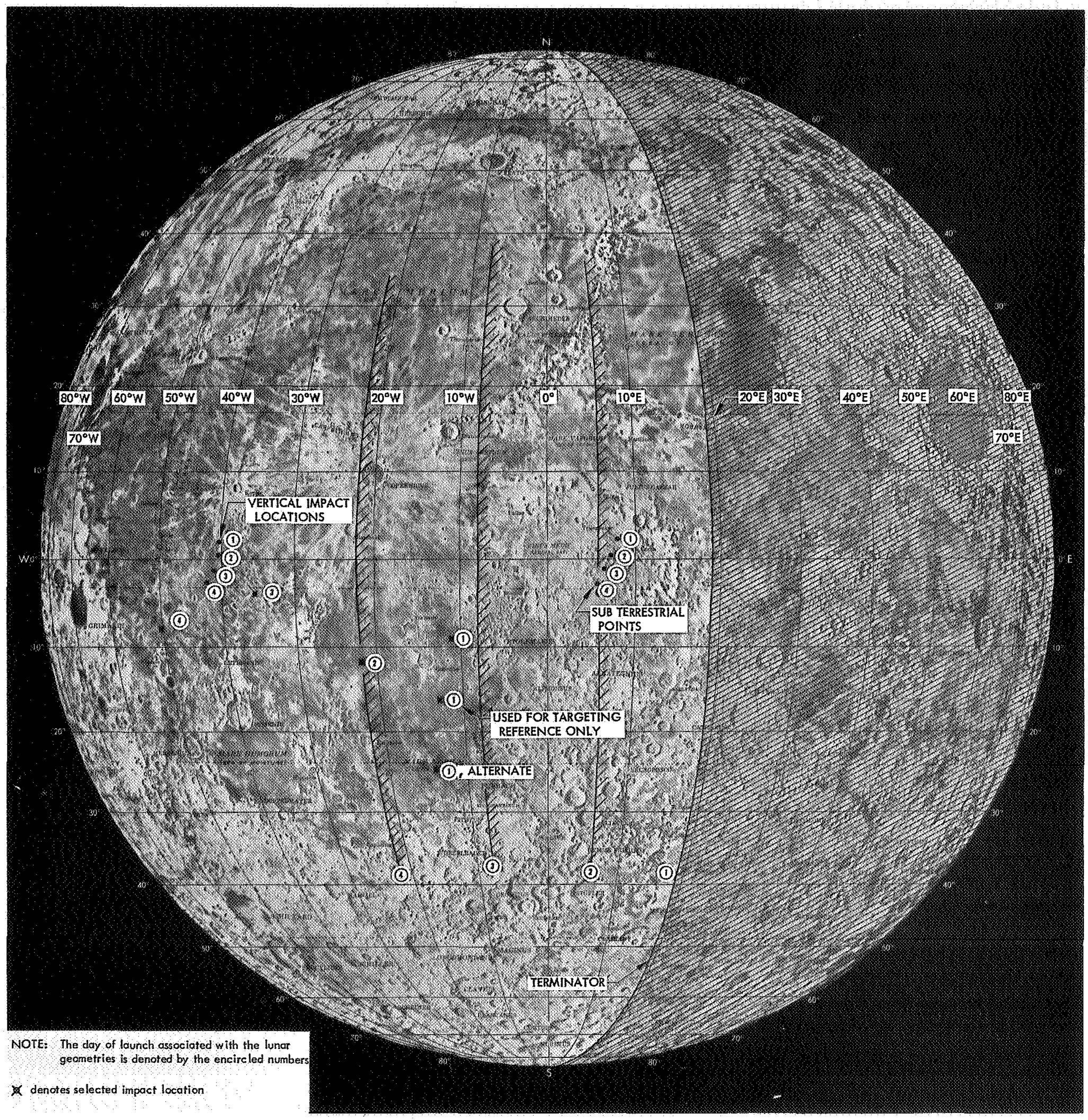
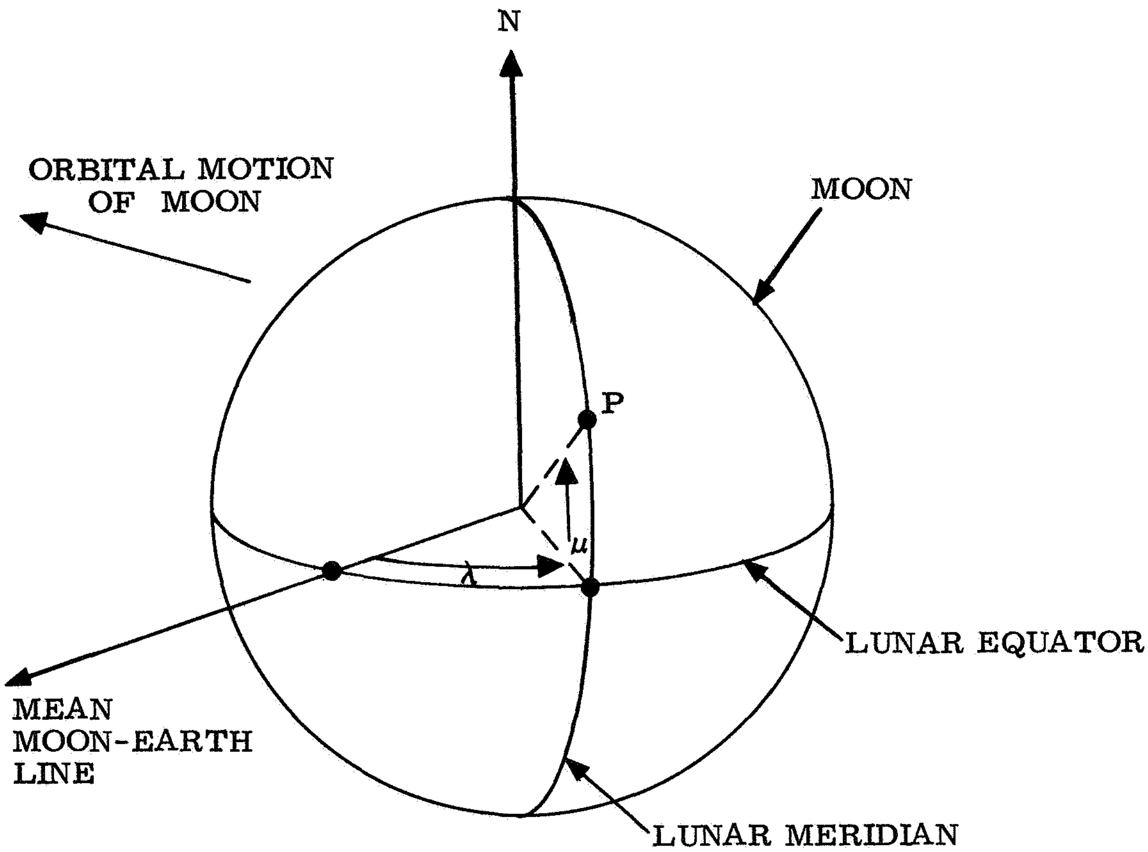


Figure 33. Lunar Lighting and Trajectory Geometry at Impact of Probe



The selenographic longitude (λ) and latitude (μ) for the point P on the moon's surface are shown in the positive directions respectively.

NOTE: The selenographic coordinates of the true Moon-Earth line are time variant.

Figure 34. Definition of Selenographic Coordinates

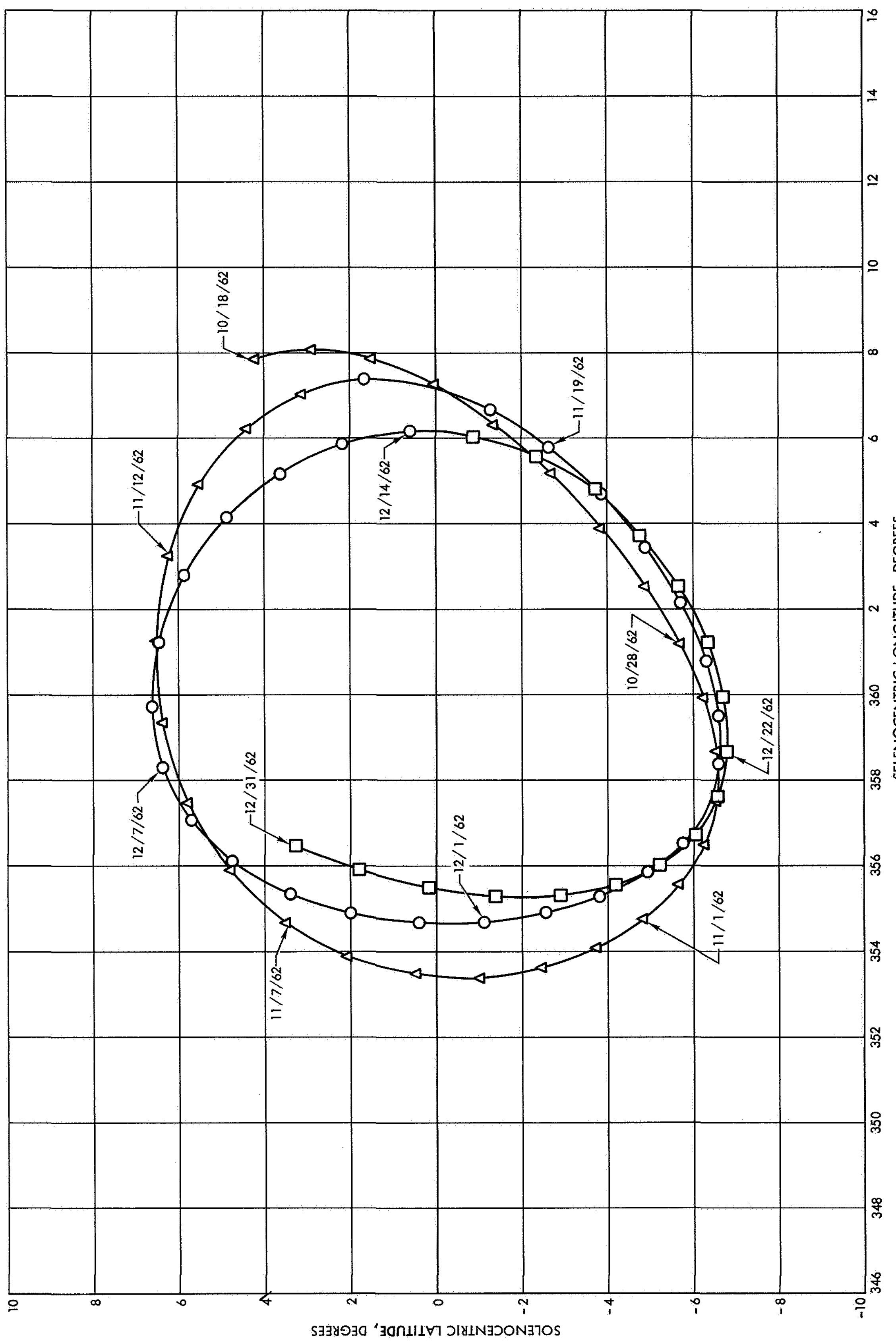


Figure 35. Selenographic Coordinates of Earth vs. Date From October to December, 1962

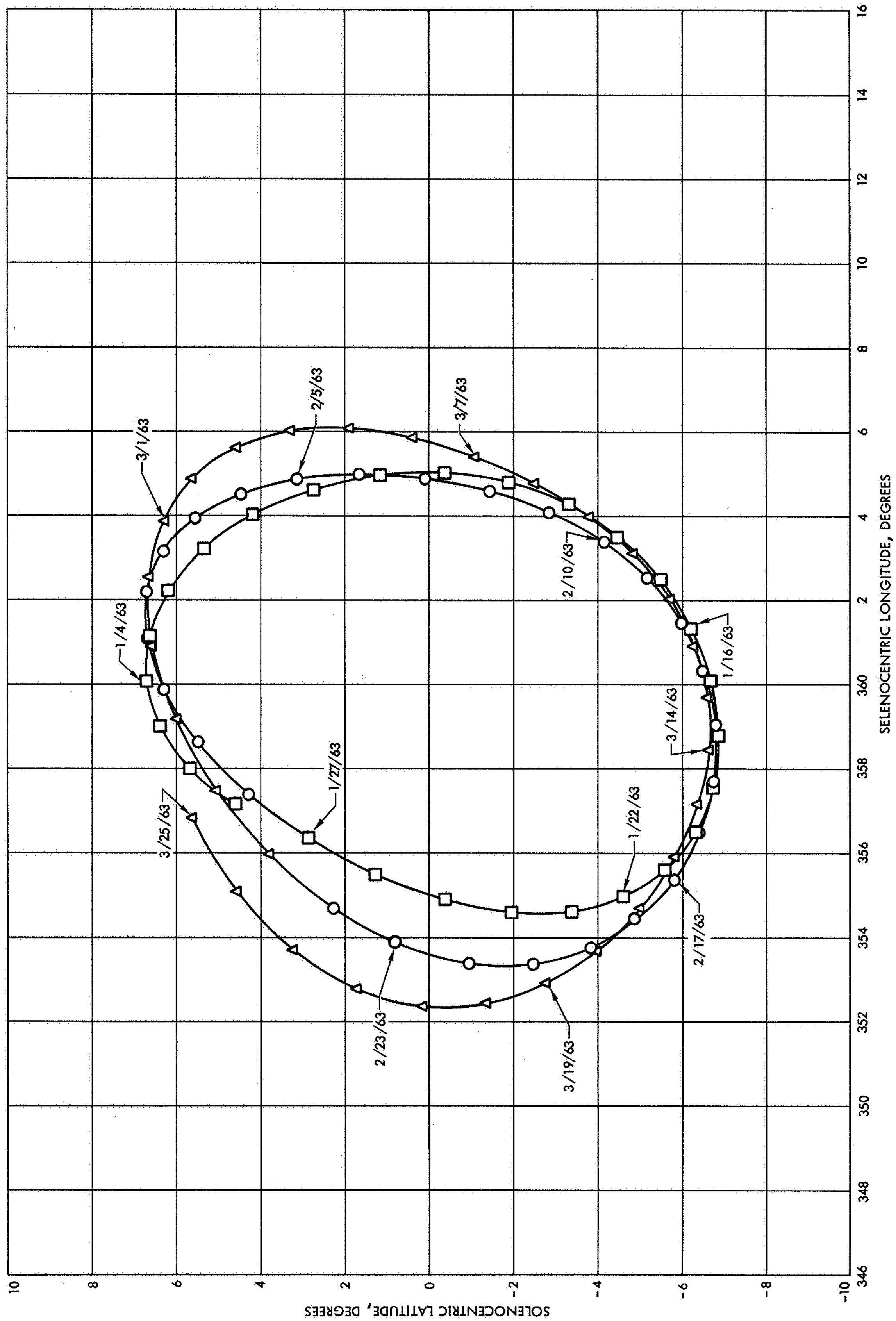


Figure 36. Selenographic Coordinates of Earth vs. Date From January to March, 1963

NOMENCLATURE

1.	Firing Window	The time interval in any one day during which firings may be attempted.
2.	GMT	Greenwich Mean Time.
3.	Launch Period	The number of consecutive days on which launchings may be attempted.
4.	Launch Time, t_L	The time at which a launching will be attempted. Lift-off time and launch time are interchangeable.
5.	Launch Azimuth	A direction in space normal to the Earth-centered radius vector, centered at the probe, and directed down range at launch.
6.	Miss Distance Vectors	Miss distances can be described by specifying two components of the impact parameter, $\vec{B}$. $\vec{B}$ the position vector in the plane of the trajectory originating at the center of gravity of the target and directed normally to the incoming asymptote of the hyperbola, is approximately the vector miss which would occur if the target had no mass.
	$\vec{S}$	A unit vector in the direction of the incoming Asymptote.
	$\vec{T}$	A unit vector perpendicular to $\vec{S}$ that lies in the orbital plane of the target.
	$\vec{R}$	A unit vector which forms the right-handed system $\vec{R}$, $\vec{S}$, $\vec{T}$. $\vec{R} = \vec{S} \times \vec{T}$.
	$\vec{B} \cdot \vec{T}$	Projection of the impact parameter $\vec{B}$ upon the vector $\vec{T}$.
	$\vec{B} \cdot \vec{R}$	Projection of the impact parameter $\vec{B}$ upon the vector $\vec{R}$.
7.	Unretarded Velocity	Trajectory condition for which no retro-rocket impulse has been applied.
8.	View Period	The interval of time during which the probe is visible to the tracking station.
9.	Vis Viva Energy, C_3	Twice the total energy per unit mass (Kilometers^2/Sec^2). $C_3 = V^2 - \frac{2GM_E}{R}$

REFERENCES

1. Space Technology Laboratories, Incorporated, Launch to Impact Targeting Trajectories, Ranger V, Volume 1 STL No. 8990-6011-TC001.

2. Jet Propulsion Laboratory, Engineering Planning Document No. 4, Standard Trajectory Atlas/Agena, Ranger 5 Postinjection.